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AGRICULTURAL EXPERIMENT STATION

EAST LANSING

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MICHIGAN STATE UNIVERSITY
AGRICULTURAL EXPERIMENT STATION
EAST LANSING

L. M. TURK, DIRECTOR
R. J. ALDRICH, ASSISTANT DIRECTOR
M. T. ALLEN, EDITOR

PUBLIC ASSISTANCE TO LAND RESOURCES IN MICHIGAN UNDER THE AGRICULTURE CONSERVATION PROGRAM

By A. ALLAN SCHMID[1]

DEPARTMENT OF AGRICULTURAL ECONOMICS

THE FEDERAL GOVERNMENT has engaged in many activities designed to aid in the development of land resources. One of these is the Agricultural Conservation Program which cost-shares with farmers in the application of certain soil and water practices. The program has contributed to the increasing productivity of the nation's soil and water resources.

This discussion is concerned with the distributional aspects of this program in Michigan and is one phase of a more general study. The distribution of funds among conservation practices and among various kinds of farmers are studied over the lifetime of the program with special emphasis on the last 10 years.

The Agricultural Conservation Program (ACP) was created in 1936 with passage of the Soil Conservation and Domestic Allotment Act. Under the Act, Class I payments were made to farmers for shifting specified percentages of their acreages of soil depleting crops such as corn to soil conserving crops such as legumes. Class II payments were made for the application of approved soil building practices such as fertilizer and green manure crops. Conservation and parity income support were closely allied at the inception of the program. However, Class I payments for reduction of the acreage of soil depleting crops were discontinued at the end of 1943.

One of the issues concerning ACP is the distribution of program payments for performing permanent, long-term practices versus short-term practices. A major directional change was made in the program in 1953, which emphasized long-term practices. This change

[1]The cooperation of Raymond Locher of the Michigan Agricultural Stabilization and Conservation Office is gratefully acknowledged.

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affected not only the distribution of funds among practices but also the distribution of funds among farmers. First, the kinds of practices affected are analyzed followed by a discussion of how this affected different kinds of farmers.

Distribution of Assistance Among Practices

The distribution of net assistance for selected groups of practices performed under the ACP in Michigan for the 10-year period 1949 through 1958 is shown in Fig. 1. Changes made in 1953 and put into effect in 1954 may be noted when the years 1953 and 1954 are compared in the diagram. One of the major groups of practices involved establishment of vegetative cover for protection against wind or water erosion. The three components of this group of practices, shown in Fig. 1, are application of lime, application of other minerals (fertilizers), and other components including seed and seedbed preparation.

The average proportion of the total ACP assistance paid in the

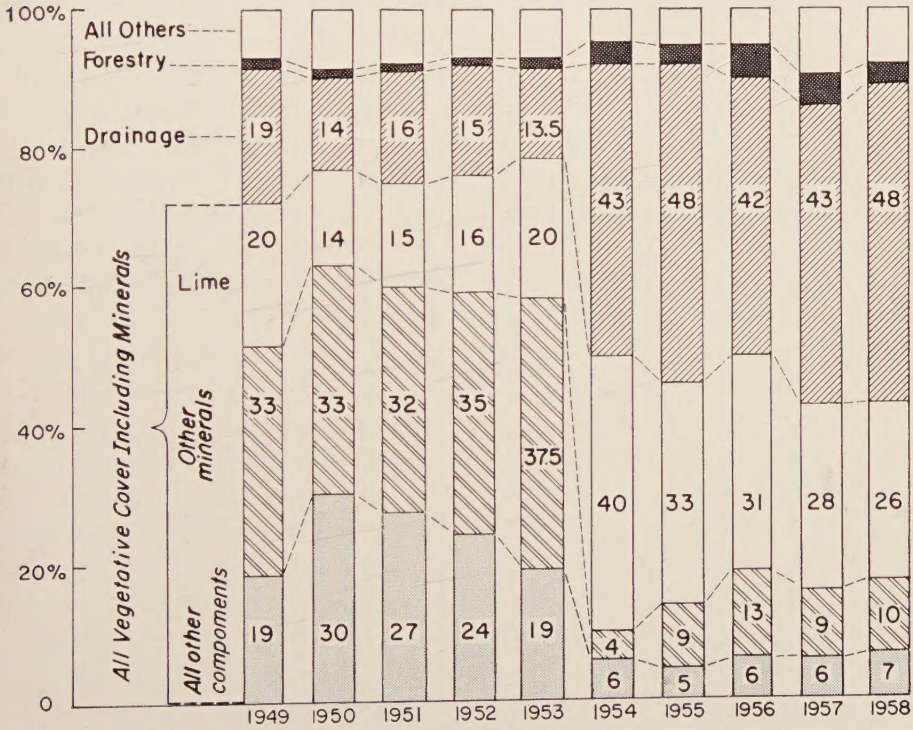

Fig. 1. Distribution of net assistance for selected groups of practices performed under the ACP, Michigan, 1949-1958.

period 1949 through 1953 for lime was 17 percent. This increased to 32 percent for the 1954-58 period. Other minerals averaged 34 percent in 1949-53 but dropped sharply to 9 percent in 1954-1958. The other components of vegetative cover also dropped sharply from 24 percent to 6 percent of the total ACP assistance. The practice of drainage took up the slack as it trebled from 15 to 45 percent in the two periods. Forestry increased also from about 1 percent to 4 percent. A miscellaneous category of all other practices increased from about 6 to 7 percent of the total. The reasons for these shifts will now be examined in detail.

ACP Practice Changes

Vegetative Cover

Non-mineral components: Changes in the practices comprising the non-mineral components of the general category of vegetative cover are enumerated in Table 1. Green manure and cover crops received the most assistance in this general category. A major change was made in the green manure practice in 1954. Prior to 1954, farmers were paid $1.50 per acre for incorporating into the soil a good stand of such crops as millet, oats, sudan grass, red clover, or alfalfa. In addition, farmers could receive payments for fertilizer applied to small grains to be used for green manure or cover crops in orchards.

The available statistics do not differentiate between green manure and cover crops for the 1949-1953 period, but a green manure crop is also a cover crop in most instances. Beginning in 1954, farmers were paid only for the initial establishment of a green manure crop which included 50 percent of the cost of the seed and commercial fertilizer used. This change was representative of the changed emphasis on specific technical performance standards.

Table 1 shows that the acreage of green manure and cover crops decreased sharply between 1949-1953 and 1954-1959. The percentage of the total assistance devoted to these practices also decreased.

The goal of the changed 1954 program was to emphasize permanent practices. If the three vegetative practices included under measures regarded as permanent by the ACP Service are compared in the two periods, mixed results on the achievement of this goal are obtained. The acreage of permanent cover established in orchards and vineyards increased between 1949-1953 and 1954-1959. The acreage of permanent cover for erosion protection and pasture did not change significantly. This conclusion must be qualified because in the 1949-

TABLE 1—Acreage of all vegetative cover, ACP, Michigan, 1949-1959

	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
Green manure(*a*)	633,485	734,558	725,863	783,467	527,568	18,910	7,634	13,634	32,351	40,746	33,027
Cover crops(*b*)	—	—	—	—	—	1,137	38,742	67,126	84,012	104,748	92,135
Permanent cover in orchards and vineyards	1,080	570	210	227	56	487	598	1,328	619	611	410
Permanent vegetative cover(*c*)	21	—	—	—	—	9,950	8,345	14,316	13,378	10,899	10,761
Permanent pasture(*c*)	31,355	12,401	8,445	8,023	11,384	—	—	—	—	—	—
Additional vegetative cover in crop rotation	0	167,709	122,269	65,560	0	0	1,703	4,256	4,158	2,368	1,001
Permanent pasture improvement(*d*)	—	—	—	—	—	0	12,915	19,067	16,314	13,512	7,325

Source: *Agricultural Conservation Program Summary by States,* USDA, 1949 through 1959; corrected by ACPS Office Form 58, July 1960.

(*a*) For the years 1949-1953, statistics on green manure and cover crops were listed together. For the years 1954-1959, it includes only practice D-3 (as listed in the ACP Handbook).

(*b*) For the years 1949-1953, acreage of cover crops was included in green manure acreage. For the years 1954-1959, it includes practices D-1, D-2, and D-4.

(*c*) For the years 1949-1953, the permanent pasture classification was used, and for 1954-1959 the practice A-2, permanent vegetative cover, included permanent pasture.

(*d*) For the years 1949-1953, farmers were paid for fertilizer for pasture improvement, but no acreage data are available. For 1954-1959, the practice also included cost-sharing for seed and lime.

1953 period, pasture established was treated as a separate category, while in 1954-1959 it was included in a general practice called establishment of permanent vegetative cover for protection against erosion and for needed land-use adjustment. Though the acreage remained about the same, the percentage of total assistance used for this practice increased between the two time periods.

A large decrease in the acreage of the practice of establishing additional vegetative cover in the crop rotation occurred between the time periods. This decrease was large enough to cause a net decrease in the proportion of total assistance paid for this group of three practices regarded as permanent.

Fertilizer: A final vegetative cover practice is the improvement of permanent pasture. In the 1949-1953 period, farmers were paid for fertilizer applied to old stands of biennial or perennial legumes or perennial grasses. No acreage data are available. The practices of permanent pasture improvement were available in 1955-1959 and the acreages treated are shown in Table 1. Most of the assistance paid for this practice is for fertilizer. Since the total amount of fertilizer assistance decreased between the two time periods, it would appear that the acreage of permanent pasture improvement did not increase.

The decrease in fertilizer assistance is difficult to analyze because no acreage data on its use is available. There was a major change in the rules for the use of fertilizer, however. In the 1949-1953 period, farmers were paid at a certain rate per 100 pounds of fertilizer used for certain seedings. In the 1954-1959 period, payments for fertilizer were made as a part of a particular practice with ACP usually paying 50 percent of the fertilizer cost.

Lime: Of the three major components of the general category of vegetative cover, the application of lime has retained its relative share of the total assistance, though the trend is down since 1954 as shown in Table 2. Liming materials applied with ACP assistance account for the bulk of the total sold in the state.

The rules for ACP assistance for lime were changed with the 1954 program. Prior to 1954, farmers were paid for application of lime on a per-ton basis without a prior soil test and without specific requirements as to the crop being limed. After 1954, a soil test was required and farmers were paid 50 percent of the cost of liming materials applied to permit the use of conserving crops. Assistance is available

TABLE 2—Liming materials, Michigan, 1936-1959

Year	Tons sold in state (*a*)	Tons cost-shared ACP	ACP assistance (dollars)	ACP assistance percent of total	Farms participating in ACP liming	Acres treated (*b*)	Tons per acre
1936	195,760	.....	.....	..	.....	97,880	2.00
1937	251,909	.....	.....	..	.....	122,290	2.06
1938	156,111	.....	.....	..	.....	75,780	2.06
1939	294,467	294,467	.....	..	.....	142,950	2.06
1940	294,132	294,132	.....	..	23,365	205,713	1.43
1941	444,194	444,194	.....	..	42,582	245,247	1.81
1942	705,206	702,927	.....	..	48,098	351,464	2.00
1943	416,500	601,133	.....	..	31,761	232,147	2.59
1944	559,067	561,362	.....	..	36,722	288,864	1.94
1945	596,829	599,410	.....	..	32,455	224,168	2.67
1946	968,394	970,402	2,033,132	..	43,272	483,324	2.01
1947	902,279	904,828	1,936,463	27	37,427	457,151	1.98
1948	705,662	708,067	1,182,383	24	32,116	368,291	1.9
1949	688,358	688,358	1,227,483	20	32,000	343,997	2.0
1950	525,335	525,335	907,700	14	23,568	260,840	2.0
1951	525,115	525,115	949,746	15	21,418	265,231	2.0
1952	535,920	535,920	728,201	17	22,768	287,064	1.9
1953	480,161	480,161	798,345	22	20,260	233,456	2.0
1954	270,427	263,462	629,410	40	8,564(*c*)	137,030(*c*)	1.9
1955	326,714	327,358	828,861	33	8,009(*c*)	151,498(*c*)	2.1
1956	418,000	410,062	1,104,165	30	8,838(*d*)	171,284(*d*)	2.4
1957	508,524	427,525	1,270,087	28	8,481(*d*)	165,558(*d*)	2.6
1958	463,261	424,828	1,231,592	25	8,111(*d*)	158,986(*d*)	2.7
1959	380,278	317,342	933,743	23	6,349(*d*)	117,967(*d*)	3.7

Source: *Agricultural Conservation Program Statistical Summary,* USDA, selected years.

(*a*) *Michigan Agricultural Statistics,* Michigan Department of Agriculture, 1960, p. 51. These are estimates.

(*b*) In 1937, 1938, 1939, estimated and revised on basis of rates of application adapted to obtain comparability with other years.

(*c*) Does not include any acreage on farms on which assistance for liming materials was given under any practice other than liming to permit use of conserving crops.

(*d*) Also includes liming orchards and vineyards.

only if the farmland is (or will be in the next year) actually planted to specified legumes and grasses.

The total assistance paid for liming reached its lowest point in 1954 and then increased in the succeeding years to the former 1947-1948 levels. However, the number of farms receiving assistance for lime and the acres treated fell sharply and did not recover to pre-1954 levels. The rate of application did increase slightly between the two time periods.

Drainage

The most spectacular result of the 1954 program changes was the large increase in assistance or drainage which accounted for 48 percent of the total assistance in 1958. This increase resulted from additional performance requirements being placed on most other practices and the fact that increased technical and cost-share assistance was made available.

For the first time in 1949, the Congress authorized the use of 5

percent of ACP funds for technical assistance. However, no sizable amounts were spent for technical assistance until the 1952 program when the Soil Conservation Service became responsible for technical assistance. One hundred thousand dollars was spent for SCS technical services in 1952 and this increased to $235,000 in 1958. Some assistance is also supplied by the Forest Service.

This increased technical assistance was especially important in encouraging drainage because it is a practice which a farmer can not usually plan successfully by himself. This is especially true for tile drains which surpassed the acreage drained by open drains for the first time in 1952 and now account for the bulk of assistance for drainage as shown in Table 3.

Another important factor in the increase in drainage was the increase in cost-share assistance in 1953 and in 1957. This resulted in the average cost-share per acre drained with enclosed drains to increase from $11 in 1949 to $36.57 in 1958 (Table 7). The acres drained and number of farms participating did not increase between

TABLE 3—Drainage, under ACP, Michigan, 1942-1959

	Open ditches			Enclosed drains		
	Acres	Farms	Assistance (dollars)	Acres	Farms	Assistance (dollars)
1942	40	11	(*b*)	0	0	0
1943	1,500	214	(*b*)	0	0	0
1944	319,200	9,937	(*b*)	16,500	2,549	(*b*)
1945	298,200	10,130	(*b*)	21,400	3,463	(*b*)
1946	493,000	12,954	708,316	39,800	4,648	247,794
1947	493,814	12,123	587,342	103,326	5,249	333,725
1948	552,884	11,867	648,048	42,361	5,963	580,106
1949	305,511	11,533	626,952	47,126	6,441	519,066
1950	209,855	9,360	398,895	42,022	5,166	399,161
1951	148,648	7,192	405,094	47,682	4,695	616,470
1952	52,285	3,005	242,347	54,883	4,022	783,146
1953	36,525	1,682	149,983	29,068	2,198	496,014
1954(*a*)	—	—	—	—	—	—
1955	34,567	1,534	216,664	41,341	3,070	988,635
1956	32,100	1,446	224,756	45,321	3,341	1,272,737
1957	25,875	1,066	191,538	47,016	3,466	1,751,400
1958	26,587	1,069	203,542	56,903	4,201	2,082,629
1959	14,325	637	119,561	41,005	3,288	1,576,673

Source: *Agricultural Conservation Program Statistical Summary*, USDA, selected years. Corrected by ACPS Office Form 58, July 1960.

(*a*) Available statistics for 1954 did not differentiate between open and enclosed drains. A total of 52,015 acres were drained on 3,988 farms with a total assistance of $686,997.

(*b*) Not available.

1949-1953 and 1954-1959 as might have been expected from the large increase in total assistance for drainage in the latter period.

The increased assistance was absorbed by the increased rate of cost-share per acre. Since 1957, ACP has paid 30 percent of the cost in certain counties where drainage is prevalent and 50 percent of the cost in the other counties. In counties where drainage is prevalent, it receives the bulk of the total ACP assistance paid in the county. For example, in Arenac County 92 percent of the total assistance was paid for drainage in 1959.

Forestry

Forestry practices received a higher percentage of the total ACP assistance in the 1954-1958 period than in 1949-1953. Under the old program, ACP cost-shared for tree planting for reforestation, gully control and windbreaks. In 1954, payments were added for forest improvement by pruning and fencing and in 1956 the practice of thinning was added and the rate of payment was doubled for tree planting.

All Other Practices

Program changes in 1954 had a marked effect on the composition of practices in this miscellaneous category. This category was composed of clearing land, weed control, and mulching which were abolished in 1954. There was a negligible amount of assistance for mechanical practices for erosion control before 1954 and this was increased slightly. In 1956, assistance was begun for livestock water facilities. The largest item in this miscellaneous category was irrigation water reservoirs which was added in 1954.

ACP Participation and Assistance

The 1954 changes in the ACP had a marked effect on program participation and distribution of the assistance. The number of participating farms, individuals, and cropland fell sharply after 1954 as shown in Table 4. The program was reaching about half of Michigan's farms in 1949-1952 but only about 10 percent after 1954. Michigan was the second lowest state in the U. S. in the percentage of total farms participating in 1958. Though fewer farmers participated, the assistance per individual increased. Prior to 1954, the average gross assistance per payee never exceeded $71 but it was over $100 in every year thereafter and reached $269 in 1958.

The program changes begun in 1954 decreased participation so

TABLE 4—ACP participation and assistance, Michigan, 1936-1960

Year	Number of participating farms	Percent of total farms participating(*a*)	Number of payees	Cropland on participating farms (acres)	Percent of total cropland participating	Average gross assistance per payee (dollars)	Total gross assistance ACP only(*b*) (dollars)
				(000)			(000)
1936....	112,508	..	106,090	7,350	69	..	1,958
1937....	127,200	..	101,783	8,045	75	..	2,566
1938....	121,549	..	121,549	7,321	68	53	1,487
1939....	128,049	..	134,382	7,816	69	57	2,211
1940....	118,886	..	127,828	7,187	63	51	2,097
1941....	140,043	..	114,575	8,317	72	71	2,659
1942....	136,150	..	145,141	9,002	78	49	5,026
1943....	143,884	..	168,644	9,382	84	62	6,804
1944....	131,078	..	152,691	8,840	76	48	7,315
1945....	119,416	..	136,774	8,217	70	48	6,512
1946....	114,879	..	145,746	8,276	70	55	8,079
1947....	104,364	..	119,786	7,506	64	58	6,930
1948....	81,198	41	88,047	6,193	53	34	2,938
1949....	94,909	47	104,045	7,225	62	52	5,407
1950....	100,582	51	110,212	7,492	64	57	6,256.8
1951....	91,490	49	100,219	6,921	60	61	6,063.5
1952....	91,012	48	99,202	7,060	61	54	5,349.1
1953....	63,378	34	68,468	5,241	45	66	4,544.3
1954....	16,330	9	16,660	1,686	15	116	1,925.0
1955....	16,237	9	16,434	1,695	15	177	2,905.2
1956....	18,930	10	19,221	1,966	17	207	3,987.6
1957....	18,544	11	18,888	1,890	17	263	4,969.9
1958....	19,117	11	19,534	1,973	18	268	5,241.8
1959....	15,496	9	15,760	1,616	15	257	4,057.0
1960(*c*)..	16,886	(*d*)	(*d*)	(*d*)	(*d*)	(*d*)	4,550.7

Source: *Agricultural Conservation Program Summary*, USDA, selected years.

(*a*) The ACP definition of a farm used here results in a higher number of total farms than the Census.
(*b*) Does not include payments for shifting acreage from soil depleting to soil conserving crops which was discontinued in 1944.
(*c*) Estimated.
(*d*) Not available.

sharply that all of the available funds could not be used in 1954, 1955, and 1956. The percentages of funds not used were 51, 45, and 25, respectively. In 1957 and 1958, most of the available money was used but the rate of participation did not recover to pre-1954 levels. However, in 1959, about one-quarter of the total funds allocated were not used again.

Distribution of Funds

The distribution of funds among various size of payment groups shifted sharply to the larger payment groups after 1954. In 1949, over half of the total number of payments were paid to participants receiving less than $40, while only about 10 percent went to this group in 1958. This shift would be expected due to the general increase in the average size of payment.

The size of payments connected with government programs is a tough policy issue which is reflected in various limits that Congress

has voted on the program. In 1938, Congress placed a $10,000 limit on individual payments which continued until 1948 when the limit was sharply lowered to $500. It was raised to $750 in 1949 and to $2,500 in 1950. It was lowered again to $1,500 in 1954 and then raised to the present level of $2,500 in 1958.

An exception to these limits was added in 1956 allowing individuals to receive up to $10,000 if the practice was performed under a pooling agreement solving a mutual conservation problem for a number of farmers. Such a practice is drainage. A new provision was added in 1958 for the Michigan program which singles out drainage and limits such payments to $1,500 per farm.

Congress has expressed another policy favoring small payments. Since the inception of the program, there has been a provision increasing cost-share payments which total less than $200 annually. The same schedule of increases has always been used. To illustrate the amounts involved, any payment between $60 and $185 would be increased $14.

The program changes after 1954 also had a differential effect on participation by size of farm as shown in Table 5. If participation rates in 1949 and 1959 are compared, the proportional drop in the rate of participation between the two program years was greater among farms of less than 100 acres than among larger farms. The data also show a steady rise in the rate of participation as size of farm increases in 1959.

Other data are available for the entire 1950-1959 period which

TABLE 5—ACP participation by size of farm, Michigan, 1949 and 1959

	Size of farm in acres(*a*)				
	Under 10	10.1-100	100.1-220	220.1 and over	All census farms
Percent ACP participation is of census farms					
	%	%	%	%	%
1949	10	67	72	49	61
1959	2	10	17	18	14
Proportional drop in rate of participation between 1949 and 1959					
	%	%	%	%	%
	80	85	76	63	77

(*a*) Choice of size classifications and years was dictated by availability of data.

Source: *Agricultural Conservation Program Statistical Summary*, 1949, p. 77, and Form ACP-306, ACPS, August 1960.

also illustrate the differential impact of program changes by size of farm. Table 6 indicates that participating farms are larger on the average than the average of all Michigan farms and this difference increased sharply in 1954 and was maintained.

TABLE 6—Comparison of size of ACP participants and all farms, Michigan, 1950-1959

Year	Average acreage cropland per farm		Year	Average acreage cropland per farm	
	All farms	ACP participants		All farms	ACP participants
1950	59	74	1955	62	104
1951	61	76	1956	63	104
1952	62	78	1957	64	102
1953	62	83	1958	64	103
1954	62	103	1959	65	104

Source: ACPS Office Form 25, March 1960.

Effect of Program Changes

The drop in participation and increase in individual assistance is consistent with the nature of the 1954 program changes. First, generally more detailed technical requirements were placed upon qualification for assistance. For example, under the old program farmers were paid for incorporating green manure crops into the soil. Under the new program, farmers were paid for establishing the green manure crop and requirements for rate of seeding and fertilization were spelled out. Another example was the new requirement for soil tests before application of lime and fertilizer. These new requirements probably contributed to the decline in participation.

Second, the manner in which the cost-share was paid and the rate of payment affected participation. Under the old program, farmers were paid a flat rate per acre for most practices or per ton for lime and fertilizer. In 1954, most payments were changed to 50 percent of the cost. No detailed cost data are available to indicate what percent of the total practice cost was covered by the flat per acre and per ton payments under the old program. However, because of the additional requirements necessary to qualify for payment, it would appear that the farmer's out-of-pocket costs are relatively higher under the new 50 percent cost-share than under the flat per acre payments.

The average cost-share per acre for a number of practices increased

sharply after 1954 as shown in Table 7. Since the farmer had to match the ACP payment for most practices, a higher capital input was required than under the old program. This discouraged participation by the smaller farmer or the farmer who had little available capital.

Third, the factors discussed previously favoring the large increase in assistance for drainage affected who could participate and the size of individual payments. Even though crop yields can be doubled and returns increased, much potentially drainable land is not drained because of the high capital requirements.[2] ACP cost-sharing helps meet this problem but some farmers still do not have enough capital to participate in this practice which has received over 40 percent of the total ACP assistance since 1954.

TABLE 7—ACP cost-share, selected practices, Michigan, 1949-1959

	Green manure	Permanent cover and pasture	Liming		Enclosed drainage
	$ per acre	$ per acre	$ per acre	$ per ton	$ per acre
1949	1.73	3.34	3.56	1.78	11.01
1950	1.71	4.25	3.46	1.73	9.50
1951	1.71	4.40	3.62	1.81	12.93
1952	1.66	3.77	3.82	2.01	13.45
1953	1.65	2.66	4.16	1.98	17.06
1954	1.50	9.02	4.42	2.55	(a)
1955	2.95	8.51	5.28	2.53	23.91
1956	3.51	8.66	6.15	2.69	28.08
1957	1.97	9.28	7.39	2.97	37.24
1958	3.01	13.28	7.43	2.90	36.40
1959	2.35	17.60	7.45	2.75	38.45

Source: *Agricultural Conservation Program Statistical Summary*, USDA, selected years.
(a) Not available.

CONCLUSIONS

A reorientation of ACP beginning with the 1954 program resulted in significant changes in the allocation of assistance among various practices and in program participation. Some of the important changes were the emphasis on long-term practices, higher technical performance standards, and further de-emphasis of the farm income support aspect which was important when the program was first created. The biggest practice decrease was assistance for fertilizer and green manure. The largest increase was for drainage.

[2]C. R. Hoglund, "Investments in Drainage Pay Off," *Sugar Beet Journal*, June, 1955.

One goal of the program change was to emphasize the establishment of permanent, long-term conservation practices. Though questions arise as to what is a permanent practice, it appears that the changed program was successful in shifting more assistance to practices which are non-recurring and more permanent to a degree. The practical result, however, was to treble the assistance paid for drainage which immediately increases production as did some of the other practices that were discontinued or restricted.

The program changes also affected participation. About half of Michigan's farms participated in 1949-1952 but only about 10 percent participated after 1954. The number of individuals receiving assistance fell from 110,212 in 1950 to 15,760 in 1959. As participation decreased, the amount of assistance per payee increased over four times.

This analysis provides a background from which additional questions may be asked for a more complete evaluation of the program. Additional research is needed on the success of program objectives,[3] and whether the present distribution of funds among practices and farmers best meets society's conservation needs. The social returns of public investment in the Agricultural Conservation Program need further study along with how the program fits into the total picture of public assistance to rural resources and people.

[3]For previous research on this point see, Pickrel, Luther and D. E. Hathaway, (1954). "Agricultural conservation payments and farm practices," Mich. Agr. Expt. Sta. Quart. Bul. *Vol. 36*: 318-330.

BREEDING EGGPLANTS FOR RESISTANCE TO VERTICILLIUM WILT

By JOHN L. LOCKWOOD and D. MARKARIAN[1]

VERTICILLIUM WILT is a common and often destructive disease of eggplants in Michigan and elsewhere. In recent years, total losses have increased in frequency to the extent that many growers have discontinued culture of this crop.

SUMMARY

Individual plants of eggplant *(Solanum melongena)*, resistant to *Verticillium albo-atrum*, were found by evaluating plant introductions. Lines uniformly resistant to Verticillium wilt were obtained through selection and inbreeding, first using a single isolate of *V. albo-atrum* and later a composite of six isolates of the fungus. Resistant selections have been crossed with standard varieties, and the advanced generations having resistance and commercially acceptable fruit and plant types are being evaluated in grower fields.

METHODS

Eight isolates of *Verticillium albo-atrum* were used and were obtained as follows: 4, 9, 93, 94, and 95 were isolated from eggplants, 5 and 77 from tomato, and 76 from potato. All isolates produced microsclerotia in culture, and all were proven pathogenic on Black Beauty eggplants. Cultures were maintained on potato-dextrose agar, and 7-day old cultures on this medium were used to inoculate seedlings in the greenhouse. For inoculation of plants to be evaluated in the field, cultures grown on corn meal-sand medium were used. This medium was prepared by steaming a mixture of 1000 g sand, 200 g corn meal, and 250 ml of distilled water, then remixing and dispensing

[1]Respectively, department of botany and plant pathology and department of horticulture. Earlier breeding work in this project was done by J. C. Ballard, formerly of the department of horticulture, Mich. State Univ. and now assistant director of the Utah Agricultural Extension Service.

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the medium into wide mouth liter flasks to a depth of 2 in., and autoclaving for 1 hour on each of 2 successive days. Following inoculation of the medium, flasks were shaken daily to assure a uniform growth and to prevent the mycelium from binding the medium into a solid cake.

The eggplant varieties evaluated for resistance to wilt were plant introductions of *Solanum melongena* which had been selected for resistance to this disease in 1950 by O. S. Cannon of the Utah Agricultural Experiment Station.

For greenhouse evaluation of wilt resistance, seedlings were germinated in Vermiculite. The roots were dipped in a 1:1 mixture of a 7-day old culture of *V. albo-atrum* on potato-dextrose agar and water, and transplanted into steamed soil. For field evaluation of wilt resistance, plants growing in flats in the greenhouse were inoculated when they were about 4 in. tall, and 1-2 weeks before transplanting, by placing 4-5 grams of corn meal-sand culture of *V. albo-atrum* into an opening made in the soil with a knife at about ½-1 in. distance from the plants. Plants of the variety Black Beauty were included as controls in all greenhouse and field experiments. These plants seldom escaped the disease. For example, in 1960 all of 54 plants of Black Beauty inoculated and transplanted in the field became diseased.

Selections of resistant plants in the greenhouse were made on the basis of freedom from external symptoms. In the field, lack of vascular discoloration was an additional criterion. On occasions, symptoms were evaluated quantitatively by using a disease scale. A rating of 0 was given healthy plants; 1, moderately wilted or stunted plants, or plants with vascular browning only; 2, plants both wilted and stunted, or severely wilted; 3, plants severely wilted and also stunted; 4, dead plants.

The hybrids between the resistant introductions and commercial varieties were made in the greenhouse. Parent plants were selected at fruit maturity in September, severely pruned, and transferred to the greenhouse in large pots. Good fruit set was obtained by maintaining temperature at approximately 24°C. and supplementing day length to 16 hours with 200-watt incandescent lamps. Subsequent segregating generations were selfed or sibbed in the field or greenhouse with the overall progress of two generations per year.

RESULTS

In the summer of 1956, six plants (S_0) of each of 50 introductions and four commercial varities of eggplant were inoculated with isolate 9 of *V. albo-atrum* and planted in the field. Fruit from 27 disease-free plants, representing 23 of the introductions, were collected in the fall. Twenty-four seedlings (S_1) from each of these fruits were evaluated for resistance to wilt (isolate 9) in the greenhouse in the winter of 1956-1957. Twenty-one of the 27 progenies had average disease indices of 1.0 or less, and resistant plants with indices of less than 1.0 were observed in all lines (Table 1). Several lines had very low average disease indices, indicating both low frequency of infection and mild disease symptoms.

TABLE 1—Disease indices of progenies (S_1) from 23 plant introductions evaluated in a greenhouse test for wilt disease caused by Verticillium albo-atrum isolate 9 (1957)

Eggplant introduction	Disease index(*a*)	Eggplant introduction	Disease index(*a*)
116677	0.2	169667	0.6
120776	1.2	171847	1.4
120787	0.7	173104	0.1
120790	0.2	173105	0.6
120790	1.0	174362	0.3
120796	1.0	175916	1.0
164941	0.7	175918	2.1
166946	0.7	176761	0.4
167328	0.3	176761	0.6
167381	0.1	179046	1.3
167381	0.1	179494	0.6
169649	1.3	179498	0.4
169650	0.7	181895	0.5
169657	1.1	Black Beauty	3.2

(*a*) Disease index was based on a scale of increasing disease severity from 0-4. Figures are the mean index of 24 plants.

In the same winter (1956-1957), each of 24 seedlings (S_1) of nine selected introductions (P.I. numbers 116677, 120796, 164941, 167328, 167381, 169667, 173104, 174362, and 176761), which showed resistance to isolate 9, were inoculated in the greenhouse with isolates 4, 5, 9, 76, and 77 to determine if they were resistant to isolates other than isolate 9. The results (Table 2) indicated that individuals resistant to each of the 5 isolates were present in these progenies. The progeny of P.I. 164941 exhibited resistance to all isolates, whereas the other introductions exhibited variable resistance. The variety Black Beauty

TABLE 2—Response of S_1 progenies of 9 selected eggplant introductions to 5 isolates of Verticillium albo-atrum in a greenhouse test (1957)

Eggplant introduction	Disease index of eggplants inoculated with various isolates of *V. albo-atrum*(*a*)				
	4	5	9	76	77
116677	2.9	2.2	0.4	1.5	3.3
120796	2.6	2.6	1.8	1.8	3.6
164941	1.9	1.0	1.4	0.4	1.5
167328	2.6	—	1.5	—	—
167381	1.8	1.1	0.4	1.3	3.3
169667	3.0	3.3	1.7	1.3	3.7
173104	2.9	2.8	0.2	1.8	2.8
174362	0.5	—	0.9	—	—
176761	1.6	1.0	1.2	1.6	2.5
Black Beauty	3.5	3.2	2.8	2.1	3.7

(*a*) Disease index was based on a scale of increasing disease severity from 0-4. Figures are the mean index of 24 plants. LSD 5% =0.8.

had the lowest level of resistance. Because of the heterogeneity of these S_1 progenies, with respect to wilt resistance, they could not be used as differential varieties to determine if the five isolates were distinct pathogenic races of the fungus. However, it appeared that isolates 4 and 5 were very similar, and that isolates 9, 76 and 77 were distinct from these and from each other. Resistant plants from each of these S_1 lines were transplanted to the field in 1957 and seed (S_2) harvested in September of 1957.

In the winter of 1957-1958, resistant selections from six (S_2) lines derived from eggplant introductions 120796, 164941, 167381, 169667, 174362, and 176761 were all inoculated separately with isolates 4, 9, 77, 93, 94, and 95 of *V. albo-atrum* and with a composite of all six isolates. There were apparently resistant plants in all lines, even when inoculated with the combined isolates. Forty selected plants (S_2) from each line were reinoculated with the composite of six isolates and planted in four replications in the field in 1958 (Table 3). All lines but one were more resistant than Black Beauty to Verticillium wilt.

Two of the lines, derived from eggplant introductions 164941 and 174362, were highly resistant to this mixture of isolates. In 1959 and 1960, inbred lines (S_3 and S_4, respectively) derived from these introductions were inoculated with the same combination of isolates of the pathogen and grown in the field (Table 4). Some of these lines were apparently homozygous for resistance to Verticillium wilt. In

1960, only six of 260 plants, representing 23 lines derived from this material, were susceptible. Four of these were from a single line (Table 4).

Plants resistant to Verticillium wilt, which were selected in 1956, 1957, and 1958 in tests described above, were crossed with Black Beauty. Progenies from these crosses have been selected for horticultural characteristics and for wilt resistance in subsequent seasons, at first using isolate 9 of *V. albo-atrum*, and in 1959 and 1960 with the combined six isolates. Some lines have been inbred following the initial cross and others have been back-crossed to Black Beauty. Some lines are now in the F_3 and F_4 generations, and are quite uniform for disease resistance and in appearance. Lines with various fruit and plant types are being developed.

The inheritance of resistance to Verticillium wilt in eggplant has not been studied, but field observations suggest that resistance is recessive. Inoculated plants from F_1 seed were always uniformly diseased; those from F_2 seed had more susceptible than resistant plants.

TABLE 3—Response of S_2 progenies of six selected eggplant introductions to a composite of six isolates of V. albo-atrum in a field test (1958) (a)

P.I. No.	Disease incidence(b)
120796	20
164941	3
167381	18
169667	33
174362	3
176761	26
Black Beauty	38

(a) The lines were resistant in the S_1 generation to various single isolates of *V. albo-atrum*. The mixture of isolates included numbers 4, 9, 77, 93, 94 and 95.
(b) Number of diseased plants of 40 tested. LSD 5% =9.

DISCUSSION

The results obtained in this program thus far suggest that resistance to Verticillium wilt can be obtained in eggplant introductions. Resistant varieties with acceptable horticultural characteristics can be obtained through selecting within eggplant introductions, or by using these as sources of resistance in crosses with standard varieties.

TABLE 4—Disease incidence in field-grown inbred lines (S_4) from eggplant introductions selected for resistance to a composite of six isolates of V. albo-atrum (1960) (a)

Line No.	P.I. No.	No. diseased/ No. planted
1	164941	0/12
2	120796	0/12
3	174362	4/9
4	164941	0/12
6	173104	0/12
8	120796	0/8
9	120796	0/10
10	120796	0/12
12	176761	0/12
17	173104	0/12
18	173104	1/12
19	173104	0/10
20	176761	0/11
21	176761	0/10
22	164941	0/7
48	164941	0/9
49	167381	0/11
50	120796	0/11
51	120796	0/12
52	164941	0/12
53	174362	0/12
54	120796	1/10
68	120796	0/12
	Total	6/250
	Black Beauty	54/54

(a) The isolates used were numbers 4, 9, 77, 93, 94 and 95.

Whether the lines under development will be resistant to strains of the pathogen other than those used in the experimental work has not yet been determined. A mixture of six isolates, at least some of which differ pathogenically, has been used to inoculate the parental and segregating generations in an effort to approximate field conditions. In several years of evaluating resistance in the same field, no loss of resistance has yet been observed. Due to the variability of this fungus, it would not be surprising if resistance would not last indefinitely. If this should occur, a vigilant program of breeding and selection might keep pace with the changing fungus. Promising lines are in grower field trials this year.

FURTHER RESULTS FROM THINNING A SPRUCE-FIR STAND

By MAURICE W. DAY

DUNBAR FOREST EXPERIMENT STATION

A SERIES OF THINNING PLOTS was established in 1940 in a 30-year-old stand of spruce-fir at the Dunbar Forest Experiment Station. A previous article by the author, described the results obtained during the first 10 years after treatment. This report presents results during the decade following. During the 20-year period, more plots and treatments have been added to the original study.

The plots are located in an even-aged stand of white spruce *Picea glauca* (Moench) Voss, black spruce *Picea mariana* (Mill) B.S.P., and balsam fir *Abies balsamea* (L.) Mill. Only a few scattered trees of other species are present. The stand occupies an upland site with a Munising stony sandy loam soil.

METHOD

Originally, three plots were thinned in the 30-year-old stand to spacings of 6 x 6, 8 x 8 and 10 x 10 feet, which left 1,210, 680, and 440 trees per acre, respectively. In 1953, four plots were added to the study, and thinned to an approximate 8 x 8-foot spacing. In addition, four control plots were also added. In 1955, two of the original plots were given a second thinning. In 1960, all of the plots were remeasured and the growth determined.

Table 1 sumarizes the data for all of the plots from 1940 to 1960. Data for the eight plots added in 1953 are listed only for 1955 and 1960, thus placing all plots on a 5-year measurement interval. The development of any or all of the plots can be determined by checking the results obtained by 5-year periods.

To accentuate the growth obtained in this stand up to age 50, a summary of the growth data is shown in Table 2.

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TABLE 1—Stocking, volume, density and average stand diameter

Plot No.	No. trees per acre	spacing	Basal area per acre(a)	Volume per acre	average DBH	Stand density index	Average spacing in percent height
		(feet)	(sq. ft.)	(cords)	(inches)		
			Before treatment—1940				
1	2,910	3.9x3.9	103	.36	2.6	340	—
2	1,940	4.7x4.7	107	2.28	3.2	312	—
3	2,320	4.3x4.3	121	4.68	3.1	355	—
4	2,210	4.4x4.4	105	3.72	2.9	305	—
			After treatment—1940				
1	1,210	6x6	54	.36	2.9	167	29
2	440	10x10	38	1.32	4.0	101	38
3	680	8x8	61	3.84	4.1	161	30
4	2,210	Control	105	3.72	2.9	305	20
			1945				
1	1,190	6.1x6.1	94	4.26	3.8	252	22
2	430	10x10	67	6.70	5.3	158	34
3	660	8.1x8.1	97	11.07	5.2	232	24
4	2,040	Control	145	9.36	3.6	395	16
			1950				
1	1,160	6.1x6.1	126	10.47	4.5	324	17
2	430	10x10	93	13.66	6.3	204	26
3	650	8.2x8.2	133	20.52	6.1	294	20
4	1,690	Control	164	15.72	4.2	422	14
			1955				
1	1,150	6.1x6.1	157	19.42	5.0	389	15
2	430	10x10	122	22.72	7.2	253	23
3	640	8.2x8.2	164	30.51	6.9	352	16
4	1,420	Control	187	25.05	4.9	456	13
6	1,640	Control	162	17.13	4.3	425	13
7	1,440	Control	174	19.08	4.7	431	14
9	1,560	Control	178	19.37	4.6	451	14
10	1,440	Control	181	20.57	4.8	445	14
			1955—After thinning				
1	790	7.4x7.4	128	17.76	5.5	303	18
3	510	9.2x9.2	141	26.56	7.1	294	18
5	710	7.8x7.8	126	17.76	5.7	288	18
8	690	8x8	116	16.04	5.6	272	18
11	620	8.4x8.4	124	19.10	6.0	273	18
12	700	7.9x7.9	104	13.22	5.2	246	18
			1960				
1	770	7.4x7.4	155	24.44	6.1	348	17
2	430	10x10	145	29.69	7.9	294	21
3	500	9.2x9.2	162	33.30	7.7	328	17
4	1,140	Control	204	33.18	5.8	432	14
5	700	7.9x7.9	156	27.13	6.4	342	16
6	1,400	Control	180	21.06	4.8	433	12
7	1,250	Control	190	26.69	5.3	452	13
8	640	8.2x8.2	138	23.65	6.3	305	16
9	1,390	Control	198	25.63	5.1	473	12
10	1,210	Control	194	29.42	5.4	451	14
11	620	8.4x8.4	151	27.22	6.7	325	17
12	700	7.9x7.9	135	21.97	6.0	307	17

(a) All trees 1-inch d.b.h. and larger.

TABLE 2—Summary of growth

Plot No.	Volume per acre 1960	Volume removed in thinning to date	Total volume produced to date	Mean annual increment at 50 yrs.	Periodic annual growth per acre				Perodic growth per acre 1956-60
					1941-45	1946-50	1951-55	1956-60	
	(cords)	(cords)	(cords)	(cords)	(cords)	(cords)	(cords)	(cords)	(cords)
1	24.44	1.66	26.10	.52	.78	1.24	1.79	1.34	6.68
2	29.69	.96	30.65	.61	1.08	1.39	1.81	1.40	6.97
3	33.30	4.79	38.09	.76	1.45	1.89	2.00	1.35	6.74
4	33.18	....	33.18	.66	1.13	1.27	1.87	1.62	8.13
5	27.13	1.62	28.75	.57	....	....	....	1.88	9.37
6	21.06	....	21.06	.42	....	....	....	.79	3.93
7	26.69	....	26.69	.53	....	....	....	1.52	7.61
8	23.65	1.71	25.36	.51	....	....	....	1.52	7.61
9	25.63	....	25.63	.51	....	....	....	1.25	6.26
10	29.42	....	29.42	.59	....	....	....	1.77	8.85
11	27.22	1.31	28.53	.57	....	....	....	1.63	8.12
12	21.97	1.84	23.81	.48	....	....	....	1.75	8.75

RESULTS

The growth of the original four plots since 1940 is quite impressive and indicates the production potential of this forest type established on suitable sites. The growth in merchantable material during the 20-year period has exceeded 1 cord per acre, per year on all of the plots, and on Plot three, which made the best growth, it amounted to 1.67 cords per acre per year.

The growth rate during the past 5-year period decreased on all plots regardless of treatment. This is due in part to a lessening amount of ingrowth of trees reaching merchantable size of 5 inches DBH. The rate of growth, as measured by the mean annual increment, tends to reach its maximum rather early in the life of a stand. Meyer (3) found that the mean annual increment reached its maximum in terms of merchantable cubic feet between 60 and 70 years of age for red spruce in the Northeast. In a study of balsam fir in the Lake States, Gevorkiantz and Olsen (2) found that the maximum for this species on good sites was reached at about 60 years. It appears now that the point of maximum mean annual increment in this study will not be reached for at least another 10, and possibly 15 or 20 years, because the current annual increment is still well over a cord per acre.

Two of the control plots, 4 and 10, showed relatively high growth

rates. An examination of these plots indicates that more than the usual expression of dominance had been attained. White spruce is especially capable of expressing dominance. A stand structure with a considerable range of diameters and differentiation into distinct crown classes permits a high growth rate on the larger trees despite the presence of many smaller trees.

The control plot with the lowest growth rate, Plot 6, was the only one that had a few aspen, *Populus tremuloides* Michx., stems. The adverse effect of such a mixture has been recognized and evaluated by Gevorkiantz and Olsen (2) in their study of balsam fir.

The plots that were thinned at age 43 averaged one-third of a cord per acre per year more growth than the control plots. While the response was not as great as that obtained by thinning at age 30, it does show the desirability of thinning, even at a later age.

CONCLUSIONS

Any study of thinning calls for the use of some index or means of measuring and evaluating the density of the stands. Two such measures are included in Table 1; namely, the Stand Density Index (SDI), originally proposed by Reineke (4), and the average spacing expressed as a percentage of the average height of the dominant trees in the stand, as proposed by Wilson (5). The stand density index is based on number of trees per acre and average diameter, and does not vary with site. In this study, the SDI has exceeded 400 on all of the control plots after age 40 has been reached. It was observed that the stand appearance indicated the need for thinning when the SDI reached 325 or higher.

When the average spacing as a percentage of height is used as an index of density, the greatest density obtained on any of the control plots is 12 percent, and all control plots fall between 12 and 14 percent. This is probably close to the maximum density for this forest type on this site. Following the original thinning in these plots, subsequent thinnings have utilized this index as a guide, and the plots have been thinned to a level of 18 percent. This is a conservative degree of thinning, and it is possible that better results might have been obtained by thinning to a level of 20 percent.

Another possible measure of stocking is bole area, which is the surface area of all trees in the stand. This surface is the cambium where growth actually takes place and is considered by some foresters

to be a true index of density. A computation of bole area in 1960 showed that the five control plots averaged 46.3 M. square feet. The thinned plots averaged 27.8 M. square feet, with Plot 2 being the lowest 24 M. Plot 4 showed a small gain in bole area during the past 5 years from 46,000 to 47,000 square feet. When plotted on the form devised by Wilson (5), the bole area of this plot follows that shown by Wilson for Norway spruce in Europe. This comparison is shown in figure 1, it indicates that the maximum bole area for this type and site is probably between 45,000 and 50,000 square feet.

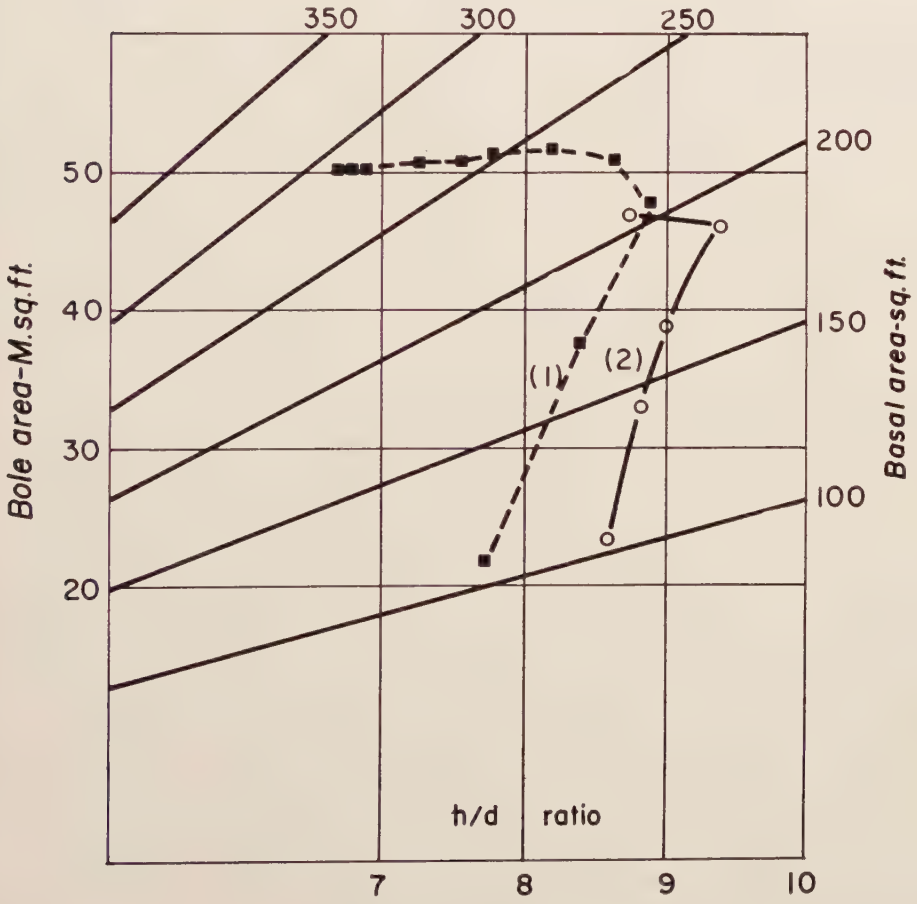

Fig. 1. A comparison of bole area in plot 4 with bole areas for similar European stands as found by Wilson (5). (1) Norway spruce, Europe, Site I, from Wilson. (2) Plot 4.

SUMMARY

This study of thinning in the spruce-fir type shows the growth response obtained by thinnings begun at 30 and 43 years of age. While all plots have made good growth, the thinned ones have produced more wood on fewer stems of larger diameter. The best mean annual increment, .76 cords, was obtained on a plot thinned at age 30 to an 8 x 8 spacing and rethinned at age 45 to a 9.2 x 9.2 spacing.

The measurement of these plots will be continued at 5-year intervals and additional thinning will be conducted in some of the plots at intervals of about 10 years. At age 60 it may be desirable to begin the first of heavier cuts to encourage the establishment of reproduction.

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A TRIAL OF SEVERAL SILVICIDES ON RED MAPLE, ASPEN AND WHITE PINE[1]

By MAURICE W. DAY

DUNBAR FOREST EXPERIMENT STATION

MANY SILVICIDES and methods of applying them are now available for controlling undesirable trees in forest stands. The injection method, and variations of the frill-girdle with solution method appear to be practical for use in many circumstances and were used in this study. These methods make use of a sharp-edged tool for cutting the bark, which permits the chemical to come directly into contact with the cambium layer of the unwanted stems. This study was made to compare the effectiveness of several chemicals as well as variations in the injection and frill-girdle methods of application.

METHODS

In the first portion of this study, six silvicide formulations were applied to red maple *Acer rubrum* L. For each formulation, 10 trees in the 2-inch d.b.h. class were treated with 1 ml. of undiluted chemical placed in a 1-inch cut located 1 foot from the ground. The cuts were made at an angle with a 1-inch wood chisel so that the liquid was held without any overflow.

The treatments were made on July 28, 1959 and the first examination of results was made on August 12. At that time, no effect was apparent. The following summer, two examinations were made, and the results for each silvicide used are listed in Table 1. Formulations 1, 2 and 3 are products of one company and are half the strength of formutions 4, 5 and 6, which are made by another company. If a minimum of approximately 80 percent crown kill is taken as an adequate result, then only formulations 2, 4 and 5 have achieved the desired effects.

In the second portion of the study, 2, 4, 5-T, 2-pound acid equivalent as an oil soluble amine, was applied to red maple using varying

[1]Acknowledgment is made to Dow Chemical, Midland, Mich., and Amchem Products, Inc., Ambler, Pa., for furnishing the materials used in this study.

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TABLE 1—Effect of various silvicides on red maple treated July 28, 1959

Silvicide formulation	Extent of crown kill on 7/25/60 (percent)	Extent of crown kill on 8/25/60 (percent)
1. 2,4,5-trichlorophenoxyacetic acid (2,4,5-T), 2 lb. per gallon acid equivalent as oil soluble amine	29	38
2. 2,3,6-trichlorobenzoic acid (2,3,6-TBA), 2 lb. per gallon acid equivalent as oil soluble amine	64	79
3. 2,4-dichlorophenoxyacetic acid (2,4-D), plus 2,4,5-trichlorophenoxyacetic acid (2,4,5-T), 1 lb. per gallon acid equivalent of each as oil soluble amine	34	36
4. 2,4,5-trichlorophenoxyacetic acid (2,4,5-T), 4 lb. per gallon acid equivalent, triethylamine salt, water soluble	96	99
5. 2,4,5-trichlorophenoxyacetic acid (2,4,5-T), 4 lb. per gallon acid equivalent, propylene glycol butyl ether esters, oil soluble.	66	84
6. 2-(2,4,5-trichlorophenoxy) propionic acid (silvex) 4 lb. per gallon acid equivalent, propylene glycol butyl ether ester, water soluble	36	41

amounts and concentrations on trees 2, 3 and 4 inches d.b.h. Each treatment was applied to five trees within the diameter class. The treatments were made on July 9, 1955, and a month later some leaf browning and curling was evident in the 2-inch trees. There was little effect on the 3-inch trees, and no effect on the 4-inch ones. Two examinations were made the following summer, and the results for each treatment are listed in Table 2.

Examination of the results in Table 2 shows that, in the range of treatments used, at least one dosage and concentration achieved more than the minimum 80 percent crown kill in all tree sizes except the 4-inch clash. In the 2-inch class, results with 1 ml. and up at full strength, and 1½ ml. and up at 50 percent strength are satisfactory. In the 3-inch class, 3 ml. in both full strength and 50 percent concentration were satisfactory, while in the 4-inch class, even the 4 ml. full-strength treatment was not effective.

Result with the 50 percent solution in oil are nearly comparable with those obtained with the full strength solution, indicating that this may be a practical means of reducing treatment costs.

The amount of solution required for effective results apparently does not vary as the diameter, but varies as the circumference, since the conducting tissue is located around the tree. On the larger trees, the number of cut required appears to be proportional to the circumference.

In the third portion of the study, three silvicides were applied in frill girdles to white pine *Pinus strobus L.* and aspen *Populus tremuloides* Michx. The girdles were made with a hand axe and consisted of a single row of downward slanting cuts through the bark at stump height. The frill girdles were varied from a complete girdle of the circumference, to 50 and 25 percent of the circumference girdled. Just enough silvicide solution was placed in the cut to wet it without overflowing. The treatments were made on July 15, 1959. Examina-

TABLE 2—Effect of various concentrations and treatments of 2,4,5-T, 2 lb. acid equivalent on red maple applied July 9, 1959

DBH class	Dosage and concentration	Extent of crown kill on	
		7/25/60	8/25/60
(inches)		(percent)	
2	¼ ml. full strength in 1 cut	16	20
2	½ ml. full strength in 1 cut	26	25
2	1 ml. full strength in 1 cut	62	80
2	1½ ml. full strength in 2 cuts	78	98
2	2 ml. full strength in 2 cuts	66	100
2	¼ ml. 50% in oil in 1 cut	22	12
2	½ ml. 50% in oil in 1 cut	8	15
2	1 ml. 50% in oil in 1 cut	42	45
2	1½ ml. 50% in oil in 2 cuts	72	88
2	2 ml. 50% in oil in 2 cuts	70	92
3	½ ml. full strength in 1 cut	0	0
3	1 ml. full strength in 2 cuts	32	35
3	1½ ml. full strength in 2 cuts	44	40
3	2 ml. full strength in 2 cuts	48	58
3	3 ml. full strength in 3 cuts	84	92
3	½ ml. 50% in oil in 1 cut	0	5
3	1 ml. 50% in oil in 2 cuts	22	35
3	1½ ml. 50% in oil in 2 cuts	50	70
3	2 ml. 50% in oil in 2 cuts	30	48
3	3 ml. 50% in oil in 3 cuts	54	88
4	1 ml. full strength in 2 cuts	0	5
4	2 ml. full strength in 2 cuts	0	15
4	3 ml. full strength in 3 cuts	40	63
4	4 ml. full strength in 4 cuts	34	52
4	1 ml. 50% in oil in 2 cuts	12	10
4	2 ml. 50% in oil in 2 cuts	12	25
4	3 ml. 50% in oil in 3 cuts	30	37
4	4 ml. 50% in oil in 4 cuts	28	42

tions of the results were made on August 24, 1959, and July 18 and August 24, 1960. The results for each frill treatment and silvicide used are shown in Tables 3 and 4.

TABLE 3—Effect of various silvicides and treatments applied to white pine July 15, 1959

Silvicide and treatment	Extent of crown kill on		
	8/12/59	7/18/60	8/24/60
	(percent)		
1. Girdle, 2,4,5-T amine, 4 lb. full strength	60	100	100
2. 50% girdle, 2,4,5-T amine, 4 lb. full strength	40	88	96
3. 25% girdle, 2,4,5-T amine, 4 lb. full strength	40	30	56
4. Girdle, 2,4,5-T amine, 4 lb. 25% in water	24	58	49
5. 50% girdle, 2,4,5-T amine, 4 lb. 25% in water	8	58	57
6. 25% girdle, 2,4,5-T amine, 4 lb. 25% in water	8	24	35
7. Girdle, 2,4,5-T ester, 4 lb. full strength	40	64	72
8. 50% girdle, 2,4,5-T ester, 4 lb. full strength	24	18	8
9. 25% girdle, 2,4,5-T ester, 4 lb. full strength	0	18	17
10. Girdle, 2,4,5-T ester, 4 lb. 25% in oil	8	42	58
11. 50% girdle, 2,4,5-T ester, 4 lb. 25% in oil	0	26	20
12. 25% girdle, 2,4,5-T ester, 4 lb. 25% in oil	0	10	0
13. Girdle, 2,3,6-TBA amine 2 lb. full strength	30	70	100
14. 50% girdle, 2,3,6-TBA amine, 2 lb. full strength	0	40	42
15. 25% girdle, 2,3,6-TBA amine, 2 lb. full strength	0	40	8
16. Girdle, 2,3,6-TBA amine, 2 lb. 25% in oil	16	24	80
17. 50% girdle, 2,3,6-TBA amine, 2 lb. 25% in oil	0	18	5
18. 25% girdle, 2,3,6-TBA amine, 2 lb. 25% in oil	0	12	0
19. Girdle, 2,3,6-TBA amine, 2 lb. 10% in oil	0	34	49
20. 50% girdle, 2,3,6-TBA amine, 2 lb. 10% in oil	0	6	2
21. 25% girdle, 2,3,6-TBA amine, 2 lb. 10% in oil	0	6	4

RESULTS

The results demonstrate the superiority of the complete frill girdle over the partial girdles. On aspen, the complete girdle was effective with all formulations and concentrations, except the diluted 2, 3, 6-TBA product. On white pine, the complete girdle was effective only with the full-strength solution of 2, 4, 5-T amine and 2, 3, 6-TBA, and the 25 percent strength 2, 3, 6-TBA solution.

The 50 percent frill girdle was effective with some of the formulations, which indicates a possibility for reducing costs inasmuch as a partial girdle is cheaper to make and requires less silvicide. In white pine, the full strength 2, 4, 5-T amine was effective with 50 percent girdles. In aspen, the 50 percent girdles were effective with full strength 2, 4, 5-T amine and 2, 4-D amine. Even the 25 percent

TABLE 4—Effect of various silvicides and treatments applied to aspen July 15, 1959

Silvicide and treatment	Extent of crown kill on		
	8/12/59	7/18/60	8/24/60
		(percent)	
1. Girdle, 2,4,5-T amine, 4 lb. full strength	84	100	100
2. 50% girdle, 2,4,5-T amine, 4 lb. full strength	95	86	92
3. 25% girdle, 2,4,5-T amine, 4 lb. full strength	36	54	53
4. Girdle, 2,4,5-T amine, 4 lb. 25% in water	65	100	100
5. 50% girdle, 2,4,5-T amine, 4 lb. 25% in water	40	80	63
6. 25% girdle, 2,4,5-T amine, 4 lb. 25% in water	65	58	56
7. Girdle, 2,4-D amine, 4 lb. full strength	100	100	100
8. 50% girdle, 2,4-D amine, 4 lb. full strength	100	100	100
9. 25% girdle, 2,4-D amine, 4 lb. full strength	60	78	81
10. Girdle, 2,4,5-T ester, 4 lb. full strength	92	100	100
11. 50% girdle, 2,4,5-T ester, 4 lb. full strength	28	48	50
12. 25% girdle, 2,4,5-T ester, 4 lb. full strength	16	54	41
13. Girdle, 2,4,5-T ester, 4 lb. 25% in oil	95	100	100
14. 50% girdle, 2,4,5-T ester, 4 lb. 25% in oil	20	44	34
15. 25% girdle, 2,4,5-T ester, 4 lb. 25% in oil	0	44	28
16. Girdle, 2,3,6-TBA amine, 2 lb. full strength	0	93	97
17. 50% girdle, 2,3,6-TBA amine, 2 lb. full strength	0	30	9
18. 25% girdle, 2,3,6-TBA amine, 2 lb. full strength	0	24	8
19. Girdle, 2,3,6-TBA amine, 2 lb. 25% in oil	0	missing	missing
20. 50% girdle, 2,3,6-TBA amine, 2 lb. 25% in oil	0	18	8
21. 25% girdle, 2,3,6-TBA amine, 2 lb. 25% in oil	0	28	18
22. Girdle, 2,3,6-TBA amine, 2 lb. 10% in oil	0	80	60
23. 50% girdle, 2,3,6-TBA amine, 2 lb. 10% in oil	0	12	4
24. 25% girdle, 2,3,6-TBA amine, 2 lb. 10% in oil	0	26	28

girdle gave a kill of 81 per cent with the 2, 4-D amine in aspen. This latter product is cheaper than the 2, 4, 5-T, and indicates another opportunity to reduce costs.

Undesirable aspen can be efficiently controlled with one man carrying the 2, 4-D amine in a quart oiler and making the partial frill girdles with a hand axe. Dilute solutions of 2, 4-D amine may also be effective in treating aspen, but this study did not evaluate dilute solution of this product.

Wide variations were obtained in response of red maple, aspen and white pine to various silvicide formulations at different concentrations. Different methods of application also have a great influence on results obtained. The results should assist in determining economical and effective means of controlling undesirable stems of red maple, aspen, and white pine.

STUDIES OF DRY RATIONS FOR THE GROWTH AND FURRING OF MINK

By HUGH F. TRAVIS[1] and PHILIP J. SCHAIBLE

Fur Animal Project, Department of Poultry Science

INTRODUCTION

Fresh or frozen meat and fish products, which comprise from 65 to 85 percent of commercial mink foods, have the disadvantages of relatively high cost, seasonal shortages or gluts, and the need for refrigeration. Transportation of these products is expensive—yet 80 percent is water which is available locally at low cost. Equipment and labor costs for refrigeration, grinding and mixing fresh foods are also high. Spoilage of, and food poisoning from fresh products are ever present dangers. Hence, the elimination of the need for fresh or frozen animal products would lead to lower-cost, safer mink foods and more economical mink production.

Dry foods have been fed with some success to other carnivores, such as the fox and dog. Therefore, it was considered worthwhile to explore the possibility of dry rations for mink. It was hoped that dry foods could be developed which would supply optimum nutrition during all phases of the life cycle. However, it was recognized that if they were satisfactory during any phase, or could comprise a greater part of present rations, they would be of considerable economic importance to the mink rancher.

REVIEW OF LITERATURE

Travis *et al.* (8) made an attempt early (in 1949) to formulate a completely dry ration for mink. They used six adult and 15 kit mink, 10 to 12 weeks of age, in their experiments. They found the dry diet inadequate for optimum growth due to a deficiency in one or more of the amino acids, methionine, lysine and tryptophan.

Howell (4) reported that growth of mink was subnormal when

[1]Present address: USDA Agr. Research Service, Beltsville, Md.

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they were fed solely on dry rations. He suggested that the lack of protein was critical. Methionine, lysine and tryptophan apparently were not involved. Travis *et al* and Howell assumed that both palatability and digestibility were factors limiting the successful use of dry diets for mink.

Kifer (5) and Kifer and Schaible (6) improved performance with dry rations for mink by adding fat and then pelleting. The palatability of their rations was satisfactory for the dark mink used.

Recently, Gunn (2) fed growing mink a dehydrated ration which was identical in composition to the fresh meat and fish control diet. Dehydration was carried out in a steam-jacketed drier at 250°F. with 1 atmosphere of vacuum. Growth rate and food consumption were not as good on the dehydrated food as on the control ration. Gunn (3) later suggested that better results may have been obtained if the ranch ration had been vacuum-freeze dried.

EXPERIMENTAL

Two growth and furring experiments were conducted. The objective was to determine if dry rations, in meal or pellet form and with or without fresh liver, could satisfactorily replace the usual ranch-type mink food consisting of fresh or frozen meat products. Modifications of the dry diets were made with respect to levels of fat and dried yeast. In the first experiment, mink kits were fed either a dry ration or a typical ranch ration. The second test was similar in design, except that the "dry" ration was supplemented with fresh liver. Rate of growth and fur quality were used as criteria in judging the efficacy of the feeding regimes.

Experiment 1

In the first study, a total of 180 dark mink kits were allocated to nine lots made up of 10 males and 10 females each. The control, a ranch-type ration which contained fresh meat and fish ingredients, is given in Table 1. The compositions and analyses of experimental dry rations are presented in Tables 2 and 3. Rations 2, 3 and 4 were designed to test different levels of fat and were in meal form. For feeding, water was added to produce a hamburger-like consistency. Ration 2 contained about 14 percent fat on a moisture-free basis. Choice animal grease was added to rations 3 and 4 so that they contained 19 and 24 percent fat, respectively.

TABLE 1—Composition of control ranch ration

Ingredient	Percent
Horse meat	26.7
Tripe	26.6
Ocean fish	26.7
Liver	5.0
Cereal, supplemented(*a*)	15.0
Total	100.0

(*a*) Mink cereal 1001, W. K. Kellogg Company, Battle Creek, Mich.

Rations 5 through 9 were pelleted. The average pellet size was 3/16-inch in diameter and $^3/_8$-inch in length. Ration 5 contained approximately 14 percent fat and the added fat consisted of yellow grease instead of cottonseed oil as in ration 2. Rations 6 and 7 compared torula and brewers dried yeasts. In ration 8, the yeast was replaced by extra fish meal and soybean oil meal. Ration 9 was identical to ration 2 but was in pellet form rather than in meal form.

The mink were placed on experiment when they were 11 weeks of age. Weight and length measurements were made at 11, 16 and 30 weeks of age. At these ages, approximately 60, 80 and 100 percent of final body weight, respectively, are usually attained. Body measurements were made by stretching the mink on a ruler and measuring the distance from the tip of the nose to the base of the tail.

Results

The weight and length data are shown in Table 4. For the overall period from 11 to 30 weeks, mink fed the control ration 1 weighed significantly more than those fed the low-fat, dry rations 2, 5 and 7. No other experimental treatments were statistically different.

Weight gains from 11 to 16 weeks (Period A) and for 16 to 30 weeks (Period B) were then analyzed separately to locate the interval where the greatest growth effect occurred. During Period A, the control ration was significantly better than any of the dry rations with respect to weight gains. Of the dry diets, rations 8 and 9, which contained animal grease, were significantly better than ration 5 which contained cottonseed oil. During Period B, no significant differences between rations were evident. Likewise, analyses of gains in length showed no significant differences due to dietary treatment.

Five males and five females from each of the experimental rations

TABLE 2—Composition of dry rations used in experiments 1 and 2

Ingredient	Experiment 1								Experiment 2			
	In meal form			Pelleted					In meal form			
	2	3	4	5	6	7	8	9	10	11(*g*)	12	13(*g*)
Cereal mix(*a*)	17.7	17.7	17.7	17.7	17.7	17.7	17.7	17.7	14.7	14.7	14.7	14.7
Dried yeast, torula	7.5	7.5	7.5	7.5	15.0	—	—	7.5	5	5	5	5
Dried yeast, brewers	7.5	7.5	7.5	7.5	—	15.0	—	7.5	5	5	5	5
Soybean oil meal, 50%	20	20	20	20	20	20	25	20	15	15	15	15
Fish meal(*d*) 55%	20	20	20	20	20	20	25	20	30	30	30	30
Herring meal, 70%	10	10	10	10	10	10	15	10	—	—	—	—
Meat meal, 65%	5	5	5	5	5	5	5	5	—	—	—	—
Liver product(*c*)	3	3	3	3	3	3	3	3	3	3	3	3
Dried skim milk	3	3	3	3	3	3	3	3	4	4	4	4
Cottonseed oil	6	—	—	—	6	6	6	6	—	—	—	
Animal grease	—	11	16	6	—	—	—	—	15	15	23	23
Sucrose	—	—	—	—	—	—	—	—	4	4	—	—
Corn starch	—	—	—	—	—	—	—	—	4	4	—	
Vit. E & B_{12}; suppl.(*d*)	.85	.85	.85	.85	.85	.85	.85	.85	—	—	—	—
Vit. B complex suppl.(*e*)	—	—	—	—	—	—	0.2	—	—	—	—	—
Multi. vit. suppl.(*f*)	—	—	—	—	—	—	—	—	.3	.3	.3	.3

(*a*) Mink mix 1007—W. K. Kellogg Company, Battle Creek, Mich.
(*b*) Vitaproil—Maine Marine Products, Inc., Portland, Me.
(*c*) Ritaliver—Imperial Products, Wadsworth, Ill.
(*d*) Per pound: Vitamin E (20,000 IU/lb) 23 gms., B_{12} suppl. (6 mg/lb) 363 gms.
(*e*) Mg. per pound: riboflavin 2,000, pantothenic acid 4,000, niacin 9,000, choline chloride 10,000, folic acid 60.
(*f*) Per 100 pounds: Vit. A (10,000 USP/gm) 12 gms; Vit. D (3,000 IU/gm) 6 gms; Vit. E (20,000 IU/gm) 6 gms; Vit. K Menadione (8.6 gm/lb) 22 gms. and choline Cl (25%) 110 gms.
(*g*) 25% liver added.

were live-graded for fur quality. The results of the evaluation are shown in Table 5. An analysis of variance indicated no difference attributable to dietary treatments.

Therefore, it is evident that the control ration was superior to the dry rations with respect to growth rate over the entire period and from 11 to 16 weeks. The dry diets and the control ration were comparable from 16 to 29 weeks with respect to rate of growth of the kits.

TABLE 3—Analyses of rations used in experiment 1, in percentage

Ration	Moisture	Protein	Fat	Fiber	N.F.E.	Ash	Calcium	Phosphorus
"As-fed" basis								
1	68.2	13.2	6.6	.8	8.6	2.7	0.48	0.39
2	9.3	42.1	13.1	1.9	23.4	10.3	1.74	1.39
3	6.9	39.5	17.7	1.8	24.5	9.6	1.58	1.30
4	7.2	37.4	22.2	1.6	22.8	8.8	1.33	1.15
5	9.0	41.9	12.6	1.8	24.9	9.8	1.45	1.26
6	9.8	41.1	12.7	1.9	24.9	9.9	1.50	1.28
7	9.3	41.3	12.6	1.7	25.6	9.6	1.31	1.26
8	9.0	43.4	13.8	1.4	21.5	10.9	1.74	1.36
9	9.5	41.1	12.7	2.0	25.1	9.6	1.42	1.26
Moisture-free basis								
1	0	41.5	20.6	2.4	27.1	8.4	1.51	1.22
2	0	46.3	14.4	2.1	25.7	11.3	1.91	1.53
3	0	42.3	19.0	1.9	26.2	10.3	1.69	1.39
4	0	40.4	24.0	1.7	24.7	9.5	1.44	1.24
5	0	46.1	13.9	2.0	27.4	10.8	1.60	1.39
6	0	45.6	14.1	2.1	27.7	11.0	1.66	1.42
7	0	45.4	13.8	1.8	28.2	10.5	1.44	1.39
8	0	47.7	15.2	1.5	23.7	12.0	1.91	1.43
9	0	45.2	14.0	2.2	27.6	10.6	1.56	1.39

Experiment 2

The second year, the fat level in the dry diets was increased—in two instances to levels substantially higher than those generally found in commercial ranch rations, as shown in Table 6. Also, the dry diets were fed with and without fresh liver. The objectives of the latter addition were two-fold: First, to determine if fresh liver contained nutrients which would make dry diets equivalent to ranch rations, and secondly, to determine if greater amounts of dry ingredients, properly balanced, could be used in ranch rations.

TABLE 4—Average weights and lengths of mink in experiment 1

Ration	Approx. percent fat H_2O-free basis	Form of ration		Wt. at 11 weeks (gms)	Weight gains between			Weight at Nov. 21 (gms)	Length in inches		
					11-16 wks. (gms)	16-30 wks. (gms)	11-30 wks. (gms)		At 11 wks.	Nov. 21	Gain
1	21	Fresh ingredients	Males.....	908	389	249	638	1,546	13.5	16.3	2.8
			Females.....	638	206	83	289	927	12.4	14.4	2.0
			Average....	773	297	166	463	1,236	12.9	15.3	2.4
2	14	Meal	Males.....	902	190	171	361	1,263	13.8	16.3	3.5
			Females.....	653	76	100	176	829	12.5	14.2	1.7
			Average....	778	133	135	268	1,046	13.2	15.2	2.0
3	19	Meal	Males.....	915	236	243	479	1,394	13.6	16.3	2.7
			Females.....	660	75	132	207	867	12.5	14.4	1.9
			Average....	788	155	187	342	1,130	13.0	15.4	2.4
4	24	Meal	Males.....	921	280	287	567	1,488	13.5	16.6	3.1
			Females.....	645	31	121	152	797	12.4	14.2	1.8
			Average....	783	155	204	359	1,142	13.0	15.4	2.4
5	14	Pellet	Males.....	899	149	225	374	1,273	13.6	16.2	2.6
			Females.....	668	48	89	137	805	12.6	14.1	1.5
			Average....	783	98	157	255	1,039	13.1	15.2	2.1
6	14	Pellet	Males.....	895	199	240	439	1,334	13.5	16.1	2.6
			Females.....	624	76	52	128	752	12.2	14.1	1.9
			Average....	759	137	145	282	1,042	12.9	15.1	2.2
7	14	Pellet	Males.....	927	173	195	368	1,295	13.6	16.2	2.6
			Females.....	643	54	96	150	793	12.4	14.2	1.8
			Average....	785	113	146	259	1,044	13.0	15.2	2.2
8	15	Pellet	Males.....	947	254	203	457	1,404	13.8	16.4	2.6
			Females.....	632	99	72	171	803	12.5	14.0	1.5
			Average....	790	176	138	314	1,104	13.1	15.2	2.1
9	14	Pellet	Males.....	922	236	228	464	1,386	13.9	15.8	2.0
			Females.....	618	120	107	227	845	12.3	14.2	1.9
			Average....	770	178	168	346	1,116	13.1	15.0	1.9

TABLE 5—Numerical scores(a) of mink pelt grades in experiment 1

	Rations								
	1	2	3	4	5	6	7	8	9
Males:									
	6	6	4	8	6	4	6	8	4
	8	6	6	6	6	8	4	8	6
	6	6	6	2	6	6	2	6	6
	8	8	8	2	6	6	2	6	8
	8	8	2	4	6	10	6	10	6
Average.....	7.2	6.8	5.2	4.4	6.0	6.8	4.0	7.6	6.0
Females:									
	8	8	8	6	8	2	8	8	6
	8	8	6	10	8	4	6	10	8
	6	2	8	6	8	6	6	8	6
	4	2	6	2	4	6	2	8	4
	4	2	4	4	8	2	8	6	4
Average.....	6.0	4.4	6.4	5.6	7.2	4.0	6.0	8.0	5.6
Males and females: Average.....	6.6	5.6	5.8	5.0	6.6	5.4	5.0	7.8	5.8

(a) Mink graded on over-all quality in relation to each other. Highest possible score 12, lowest 0. Size and condition (fatness or thinness) not considered. Pelts graded by Mr. Joseph Stuekerjuergen, Madison, Wisconsin.

TABLE 6—Analyses of rations used in experiment 2, in percentage

Ration	Moisture	Protein	Fat	Fiber	N.F.E.	Ash	Calcium	Phosphorus
"As fed" basis:								
1.....	72.8	11.8	5.4	.62	7.2	2.5	.58	.39
10.....	49.2	20.0	11.9	.94	13.7	4.3	.72	.61
11.....	55.2	18.7	10.0	.70	12.0	3.5	.54	.54
12.....	49.0	19.4	16.2	.91	10.3	4.2	.66	.59
13.....	57.4	17.2	13.3	.75	7.9	3.4	.49	.49
Moisture-free basis:								
1.....	—	42.2	19.7	2.3	26.6	9.1	2.13	1.43
10.....	—	39.3	23.4	1.8	27.0	8.5	1.42	1.20
11.....	—	41.8	22.2	1.6	26.6	7.8	1.20	1.20
12.....	—	38.0	31.8	1.8	20.2	8.2	1.29	1.16
13.....	—	40.4	31.3	1.8	18.5	8.0	1.15	1.15

One hundred and fifty dark mink kits were allocated to five lots of 15 males and 15 females each. The mink in one lot were fed the control ration consisting of horse meat, tripe, ocean whiting, liver and cereal, as previously shown in Table 1. One dry diet was formulated to have a fat level about that of a commercial mink ration. The other dry diet contained 8 percent more fat. Both dry diets were fed with and without 25 percent of fresh liver.

For feeding the dry diets, water was added to attain a hamburger-like consistency. Experimental rations are presented in Table 2, and their chemical analyses are shown in Table 6. The mink were placed on experiment when they were 11 weeks of age. Weights and length measurements were made at 11 and 16 weeks of age, as well as on November 21 when the experiment was terminated. The performance of the animals fed the different rations is shown in Table 7.

Results

An analysis of variance of the weight gains from 11-30 weeks of age showed a significant interaction ($P < 0.01$) between sex and diet. The males gained much more proportionally than the females. For this reason, the weight gains were analyzed separately by sexes.

The gains of both the males and the females during the entire period of the experiment were significantly greater for the mink fed the ranch ration than those mink fed the dry rations. The addition of fresh liver significantly benefited the dry diets. The females on the dry diets plus liver gained proportionately better than the males. In fact, the females fed the high-fat diet with fresh liver practically equaled the weight of females fed the control diet.

An analysis of variance of the weight gains for the period from 11 to 16 weeks (Period A) and from 16 weeks to November 21 (Period B), in Table 8, showed that in Period A the control diet was best, dry diets with liver next best, and dry diets without liver poorest. On the other hand, in Period B the dry diets plus liver was best, the dry diets without liver the next best, and the control diet poorest.

DISCUSSION

The difference in performance between animals on the control diet and those on dry rations appeared to be due partly to the need for the latter animals to adjust to the texture and palatability of dry ingredients. This took a week to 10 days and the mink appeared unable to recover the weight lost during this adjusting period. Of

TABLE 7—Average weights and lengths of mink in experiment 2

Ration	Approx. percent fat H_2O-free basis	Percent fresh liver added to dry diets		Weight at 11 weeks (gms)	Weight gains between			Weight at Nov. 21 (gms)	Length in inches		
					11-16 wks. (gms)	16-30 wks. (gms)	11-30 wks. (gms)		At 11 wks.	Nov. 21	Gain
1	20	—	Males.....	951	395	223	618	1,569	14.5	16.3	1.8
			Females.....	700	186	23	209	909	13.4	14.4	1.0
			Average....	825	290	123	413	1,239	13.9	15.3	1.4
10	23	None	Males.....	979	96	210	306	1,285	14.5	15.9	1.4
			Females.....	698	25	90	115	813	14.5	15.9	1.4
			Average....	839	60	150	205	1,049	14.5	15.9	1.4
11	22	25	Males.....	984	195	312	507	1,491	14.5	16.2	1.7
			Females.....	687	55	113	168	855	13.3	14.2	0.9
			Average....	836	125	192	317	1,153	13.9	15.2	1.3
12	32	None	Males.....	987	131	156	287	1,274	14.4	15.7	1.3
			Females.....	688	24	90	114	802	13.2	13.9	0.7
			Average....	838	77	123	200	1,038	13.8	14.8	1.0
13	31	25	Males.....	959	182	248	430	1,389	14.3	15.7	1.4
			Females.....	705	72	130	202	907	14.3	15.7	1.4
			Average....	832	127	189	316	1,148	14.3	15.7	1.4

TABLE 8—Weights and weight gains of mink on dry diets in comparison to those on the control ration in experiment 2

	Total weights			Gains in weight					
	Initial wt. (gm)	Final wt. (gm)	Final wt. as percent of controls	11 wk.-16 wk.		16 wk.-Nov. 21		11 wk.-Nov. 21	
				Amount (gm)	Percent of control	Amount (gm)	Percent of control	Amount (gm)	Percent of control
Control:									
Male.....	951	1,569	100	395	100	223	100	618	100
Female ...	700	909	100	186	100	23	100	209	100
Dry diets:									
Male.....	983	1,280	82	114	29	183	82	297	48
Female....	693	807	89	24	13	90	391	114	55
Dry diet+ 25% liver:									
Male.....	972	1,440	92	188	48	280	126	468	76
Female....	696	881	97	64	34	121	526	185	89

course, this was not a factor with mink on the control diet. The increased response of mink to the dry rations during Period B may be due to the fact that animals thereon were smaller and thus more capable of further growth than heavier mink on the control ration.

In many species of animals, slower weight gains during early stages of growth are compensated for by faster gains later on. However, unpublished work by the senior author and colleagues showed that the epiphyses of the long bones of mink close at about 16 weeks of age. Such a situation would preclude any further gains in length. If so, requirements for late growth should be less critical. Perhaps this is why dry diets did well during this period.

Adult mink gradually deposit fat during the fall and lose it, little by little, during winter and spring. Much of the weight gain in kit mink after 16 weeks of age consists of fat (9). Whether fat deposition is necessary for optimum pelt development, or whether an excess or an insufficiency can reduce the quality of the pelt, has never been adequately studied.

Kifer (5) indicated in his studies that a limiting factor in the performance of mink on dry diets was digestible energy, as he obtained greater growth responses with higher fat levels. To investigate this possibility, in the present study, the digestible energy values of the control and several of the dry rations containing different fat levels were calculated and are shown in Table 9. Nutrient digestibility

was estimated as follows: dry ration—protein, 70 percent; N.F.E., 80 percent; fat, 90 percent; and for the ranch rations—protein, 85 percent; N.F.E. 90 percent; and fat, 90 percent. Crude fiber was ignored, as its digestibility approaches zero. Energy values were calculated on a basis of nine calories per gram for fat and four calories per gram for protein and carbohydrate.

TABLE 9—Estimated energy values of rations, in calories per hundred grams, moisture-free basis

Ration	Total	Digestible
Experiment 1:		
1	460	405
2	418	328
3	444	356
4	476	386
Experiment 2:		
1	453	397
10	475	385
11	474	382
12	519	429
13	517	426

On this basis, the higher-fat dry diets in Experiment 2 contained comparable levels of digestible calories to the control ration. Since weight gains of males were not as good on dry diets as for those on dry diets plus liver, and on the latter with respect to the ranch-type rations, it would appear that the fresh food was contributing some factor necessary to obtain maximum response. However, mink consume less food on dry rations than on ranch-type rations.

Since the females did better than the males on dry diets alone or dry diets supplemented with liver, either females do not need as much of whatever fresh food contributes, or they consume more of the dry feed in relation to their total weight. This indicates that successful dry rations may be developed for females with less difficulty than for males.

Both length and weight help to characterize rate of growth, but the attribute of greatest economic importance to the mink industry is pelt quality. Evaluations based on subjective judgments of fur graders leave much to be desired. Objective methods have been developed (1, 10), but they are so time-consuming that they are im-

practical for routine use. In general, it has been observed that if a diet stimulates a more rapid growth rate than another, it produces as good, and possibly a better, pelt quality. So far, there has been no indication that dry diets, per se, had detrimental effects on pelt quality.

SUMMARY AND CONCLUSIONS

Experiments were conducted with mink during two growth and furring periods to find out if rations composed of dry ingredients could perform as well as ranch-type rations composed primarily of fresh or frozen meat and fish products. A total of 330 mink were used: nine groups of 20 mink in one experiment and five groups of 30 mink in another. Dry rations were fed in the form of pellets, or a meal moistened with water to hamburger-like consistency.

Increasing the level of animal fat from about 14 to 24 percent in the dry rations improved the rate of growth of kits. No added beneficial effect was apparent from increasing the fat further to 28 percent.

Dry diets produced somewhat inferior growth in dark mink kits compared to the control, ranch-type ration. The poorer results occurred during the period from 11 to 16 weeks of age. From 16 to 30 weeks of age, dry diets produced comparable, or greater gains, than the control ration.

Females did better than males on the dry diets. Supplementing the dry food with 25 percent of fresh liver improved the rate of growth. Fed in this way, females grew practically as well as on the ranch-type ration. Brewers yeast and torula yeast gave comparable results when they constituted 15 percent of the dry ration.

There were no significant differences in length of mink or in fur quality of the live mink between ranch-type and dry diets.

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DRY DIETS FOR MINK DURING MAINTENANCE, REPRODUCTION AND EARLY KIT GROWTH

By HUGH F. TRAVIS[1] and PHILIP J. SCHAIBLE

Fur Animal Project, Department of Poultry Science

Ranch rations fed to adult mink consist principally of fresh or frozen meat and fish products with about 10 to 20 percent of dry "cereal" products. It would be economically advantageous—especially from the standpoint of costs of food, storage of foods, and labor of feeding—if dry feed ingredients could be used entirely or in substantial amounts for feeding adult mink.

Previous studies[2] have shown that rations composed of dry ingredients maintain weight of adult mink but are unsatisfactory for nourishing females during reproduction and when they are nursing their kits. Whether the poor results obtained during the latter periods were due to inadequacies in the food, methods of feeding, palatability or digestibility is not known.

To explore this situation further, dry rations with and without fresh liver were compared with typical ranch rations during two pre-breeding, reproduction, and lactation periods of adult breeder mink.

Experiment 1

Ranch and dry rations were fed to mink during the period prior to breeding, when the problem is primarily one of maintenance of weight and vigor of the animals. During the periods of gestation, parturition and lactation, the dry food was fed with and without 25 percent of ground fresh beef liver.

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[1]Present address: Animal husbandry research division, ARS, USDA, Beltsville, Md.

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The experiment was initiated January 18 and continued until the kits were 21 days of age. Twenty dark female mink were fed the control ration and 14 dark and five pastel females were fed the dry diet shown in Table 1. Water was added to the dry diet to make a mixture of hamburger-like consistency, similar to that of the control ration. Starting on March 11, at the time that the animals were bred and thereafter, 25 percent of fresh liver was added to the dry diet.

TABLE 1—Composition of rations used in experiments 1 and 2, in percentage

Control ranch ration	Dry rations	Experiment 1	Experiment 2
Horse meat.....26.7	Cereals(*b*).....	17.2	17.7
Tripe.....26.6	Soybean oil meal (50% protein).....	19.0	15.0
Ocean perch.....26.7	Dried yeast, torula.....	7.2	7.5
Liver..... 5.0	Dried yeast, brewers.....	7.2	7.5
Cereal, suppl.(*a*).....15.0	Fish meal(*c*) (55% protein).....	19.0	30.0
	Herring meal (70% protein).....	9.6	....
	Meat scraps.....	4.8	....
	Liver product(*d*).....	2.8	3.0
	Skim milk powder.....	2.8	4.0
	Choice white grease.....	10.4	15.0
	Vit. A and D suppl.....	*	....
	Multi-vitamin suppl.....	....	**

*Per 100 lbs: Vitamin A (10,000 IU/gm) 8 gms; Vit. D_3 (1,500 IU/gm) 80 gms.
**Per 100 lbs: Vitamin A (10,000 USP/gm) 12 gms; Vit. D (3,000 IU/gm) 6.0 gms; Menadione (8.6 gms/lb) 22.0 gms; choline chloride (25%) 110 gms; Vitamin E (20,000 IU/gm) 6 gms.
(*a*) No. 1001 W. K. Kellogg Co., Battle Creek, Mich.
(*b*) No. 1007 W. K. Kellogg Co., Battle Creek, Mich.
(*c*) Vitaproil—Maine Marine Products, Inc., Portland, Me.
(*d*) Ritaliver—Imperial Products, Wadsworth, Ill.

Chemical analyses of the rations are shown in Table 2. Performance data for the animals during the maintenance, reproduction and lactation periods are shown in Table 3.

Results

There were no significant differences in adult weights during the maintenance period, nor in breeding performance, between the two types of rations. Likewise, the number of kits whelped was comparable, although there seemed to be somewhat higher mortality and smaller kit weights at 21 days of age for those on the dry diet plus liver. An analysis of variance indicated the production and initial weights of mink on the dry diets with fresh liver were not

TABLE 2—Analyses of rations used in experiment 1, in percentage

Rations	Moisture	Protein	Fat	Fiber	Calcium	Phosphorus
"As fed" basis						
Control	72.4	12.1	6.3	.7	.57	.41
Dry+25% liver	60.8	20.2	7.4	.7	.46	.52
Moisture-free basis						
Control	0	43.5	22.8	2.5	2.06	1.48
Dry+25% liver	0	51.6	19.0	1.7	1.17	1.33

significantly different from those on the control ration. On the other hand, the 21-day weights of the kits from mothers on the dry diet with liver were significantly lower ($P < 0.01$).

TABLE 3—Performance of mink during winter maintenance and reproduction in experiment 1

	Ranch ration	Dry ration+ 25% fresh liver
NUMBER OF FEMALES		
Started	20	19
Bred	20	17
Repeat matings	14	11
Whelped	17	16
NUMBER OF KITS		
Born	97	91
Alive at 1 day	92	85
Alive at 21 days	87	75
Per female	4.6	5.4
Per female whelped	4.5	5.3
AVERAGE WEIGHT OF KITS IN GRAMS		
At 1 day		
Males	10.5	10.2
Females	9.9	9.4
Both sexes	10.2	9.8
At 21 days		
Males	111	100
Females	105	90
Both sexes	108	95
ADULT FEMALE WEIGHTS IN GRAMS		
Jan. 18	772	817(*a*)
Mar. 11	726	726(*a*)
July 11	817	726

(*a*) Before fresh liver addition.

Experiment 2

Since the dry diet plus fresh liver gave reasonably good results during gestation and parturition, it was decided the next year to feed the dry ration not only prior to breeding but during gestation and then supplement it with fresh animal products during lactation and early kit growth. During the latter period, the dry diet was supplemented with fresh liver or tripe. The objectives were to find out if a dry diet could be used satisfactorily during gestation, and if the beneficial effects of fresh liver were due to its special nutrient values or to improved palatability of the ration.

The experiment was started on January 21 and continued until the kits were 14 days of age. Ten dark females were fed the control ration and two lots of 10 similar minks were fed the dry diet. The compositions of the rations are given in Table 1. Starting April 25 (about 5 days before the first litter was expected to arrive) the two groups of animals, which had been on the dry ration, were fed the dry diet supplemented either with 25 percent of ground fresh tripe or 25 percent of ground fresh liver. Water was added to produce a mixture of hamburger-like consistency, similar to the ranch ration.

Analyses of the rations are given in Table 4. Breeding, whelping and kit results are shown in Tables 5 and 6.

TABLE 4—Analyses of rations used in experiment 2, in percentage

Rations	Moisture	Protein	Fat	Fiber	N.F.E. (a)	Ash	Calcium	Phosphorus
"As fed" basis:								
Control	73.6	11.3	6.0	.7	6.4	2.2	.50	.35
Dry	8.4	35.3	24.4	1.9	22.1	8.0	1.21	1.15
Dry+25% tripe	63.4	15.8	10.1	.7	6.9	3.0	.42	.42
Dry+25% liver	60.6	17.8	10.1	.7	7.5	3.2	.44	.49
Moisture-free basis:								
Control	0	42.2	22.7	2.5	24.2	8.4	1.90	1.33
Dry	0	38.5	26.6	2.0	24.1	8.7	1.32	1.25
Dry+25% tripe	0	43.4	27.7	1.8	18.9	8.2	1.16	1.16
Dry+25% liver	0	45.2	25.6	1.7	19.2	8.2	1.12	1.24

(a) Nitrogen-free extract.

Results

As in the previous year, mink on the dry ration did not gain in weight as the season progressed as much as those on the practical ranch ration. As a result, they averaged 123 grams less at breeding

TABLE 5—Female weights, breeding and whelping results, experiment 2

	Rations		
	Control (10 females)	Dry(*a*) (20 females)	Dry(*a*) (10 females)
NUMBER OF FEMALES			
Started	10	20	10
Bred	10	19	9.5
Repeat matings	7	14	7
Whelped	10	16	8
WEIGHTS OF FEMALES (grams)			
January 2	696	756	756
February 3	942	806	806
March 20	895	772	772
NUMBER OF KITS			
Born	62	89	44.5
Alive 1 day	59	80	40
Per female	5.9	4.0	4.0
Per female whelped	5.9	5.0	5.0

(*a*) Supplemented with 25% fresh liver or tripe after April 25.

TABLE 6—Kit production, weights and livability, experiment 2

	Control ranch ration	Dry ration(*a*)		
		With liver	With tripe	Averages
NUMBER OF FEMALES				
Started	10	10	10	10
Whelped	10	7	9	8
NUMBER OF KITS				
Born	62	36	53	44
Alive at 1 day	59	33	47	40
Alive at 14 days	55	29	41	35
KIT MORTALITY (percent)	10	19	23	21
KITS ALIVE AT 1 DAY				
Per female	5.9	3.3	4.7	4.0
Per female whelped	5.9	4.7	5.2	4.9
KIT WEIGHTS IN GRAMS				
At 1 day				
Male	8.8	8.6	8.4	8.5
Female	8.5	7.6	7.6	7.6
Average	8.6	8.1	8.0	8.0
At 14 days				
Male	53	57	54	55
Female	58	53	53	53
Average	55	55	54	54

(*a*) Fed alone until April 25 when it was fed with fresh liver or tripe.

time as shown in Table 5. Nevertheless, they bred as well as animals on the control ration and whelped normally.

There was an average decrease of 2.6 kits per female kept, or 1.2 kits per female that whelped, between the females that received the dry diet with liver compared with those fed the control ration, as shown in Table 6. However, even this large difference was not statistically significant, although the "F" value came very close to significance at the 5 percent level. Analysis of variance of the 1-day and 14-day kit weights did not show significant differences between the dietary treatments.

DISCUSSION

In general, the results obtained in Experiment 2 did not quite measure up to those in Experiment 1. This indicates that the feeding of fresh liver during gestation is beneficial. This shows up primarily in the relative number of kits born, but also to some extent in their weights at whelping. Kits from mothers on dry diets survived and grew as well as those from mothers on the ranch ration. This points to a weakness in the dry diets primarily during the period of the growth of the foetuses rather than during lactation.

The lack of significant differences in kit weights between different diets in Experiment 2 may have been caused in part by variation in litter size. At 14 days, mothers on the control ranch ration were nursing an average of 5.5 kits; those on the dry diet plus liver 4.1 kits; and those on the dry diet plus tripe 4.6 kits.

Kit production on dry and supplemented dry diets in this experiment was about equal to the national average. Nevertheless, it was not as good as on the control ration. Average kit production on the latter, however, happened to be outstanding for this particular year.

SUMMARY AND CONCLUSIONS

Two experiments were conducted during the maintenance and reproduction periods of adult female dark and pastel mink using dry rations supplemented at intervals with fresh animal products.

In the first experiment, mink fed a dry diet prior to breeding, with 25 percent of fresh liver added during gestation and lactation, were comparable in adult weight, breeding performance, and number of kits whelped to mink that received a typical commercial ranch

ration. There was no significant difference in 1-day kit weights, but 21-day kit weights were significantly greater in mink fed the control ranch ration.

In the second experiment, mink were fed a dry ration prior to breeding and during gestation until just before whelping. Then the dry diet was supplemented with 25 percent of either fresh liver or tripe. The females on the supplemented dry rations averaged four kits per female kept. This reasonably good performance, however, was not equal to that of the females on the control ration, which was an exceptional 5.9 kits per female kept. Kits that whelped survived and grew satisfactorily on both types of rations.

The response from the addition of fresh liver or fresh tripe to the dry diets during lactation was similar. This indicates that the value of fresh liver with dry diets may be due to improvement in palatability rather than supplying critical nutrients.

MORE EVIDENCE OF "DOMINANCE" OF THE "HEN COLORING" GENE

By EARL W. HENDERSON

DEPARTMENT OF POULTRY SCIENCE

THE POSTULATION of a gene for hen coloring of chickens, Hc, Homochromosity, was originally offered to separate hen coloring from the hen feathering Hf genom.[1] This separation was necessary to account for the unexpected phenotypes which appeared among the F_1 progeny of a Silver Laced Wyandotte x White Laced Red Cornish cross.

Henderson and Coleman[2] presented additional evidence of the existence of such a gene and the reasons for separating it from the hen feathering genom Hf. The phenotypes recorded in their investigations were "hen colored" but not "hen feathered".

More evidence of the existence of a gene for "hen coloring" is offered here from detailed data.[3]

MATERIALS AND METHODS

The Origin of Phenotypes Involved

Although the main objectives of the project were to determine the inheritance of meat type and reproductivity, color and other characteristics were recorded in each generation. They were utilized for the analysis which follows.

The project from which these data were obtained has necessarily included chickens of several color varieties, especially those of the Cornish breed. Two varieties of Cornish (Darks and Whites) were included at the start of the project. The White Laced Red variety of

[1]Henderson, E. W. (1956). Notes on the inheritance of white laced red of Cornish. Poul. Sci. 35: 781-982.

[2]Henderson, E. W. and T. H Coleman (1957). The inheritance of sexual color differences in chickens. Mich. Agr. Expt. Sta. Quart. Bul. 40: 2-9.

[3]Mich. Agr. Expt. Sta. project No. 266.

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Cornish was added shortly thereafter. A number of objective crosses have been made with other standard and non-standard varieties. Red Leghorns have been used at various times for test purposes.

Classification Based on Resemblance to Standard Color Patterns

The color patterns involved in this project are classified in reference to "standard" varieties as closely as possible. The resemblance to standard varieties is usually close enough to permit such classification by experienced poultrymen familiar with normal and or juvenal deviation from idealized standard models.

Trapnesting and Pedigree Hatching Routine

All chickens involved in the project since its inception have been identified and pedigreed, individually, as routine procedure. All hens are trapnested daily and pens are "single male mated", exclusively. Chicks are pedigreed at hatching time and classified at three ages: (1) day old, (2) broiler age, and, (3) at maturity, in case of survivors.

RESULTS

Parental phenotypes and color pattern distributions of progeny are shown in Table 1 where they are classified with respect to hen coloring.

The "Red Leghorn" sires in mating number 1 were classed as hen colored, although the strain at this station has some Dark Cornish in its ancestry. The White Laced Red females in mating number 1 are the descendants from a Dark Cornish x White Laced Red Cornish cross. Of the 16 progeny, only two (the D. C.) were definitely not hen colored. Approximately the same ratio of hen colored to sexually dichromatic phenotypes is apparent in the reciprocal cross (mating number 2).

From appearances alone, the parental stock in mating number 3 might be classed as hen colored. The W. L. Red sire in mating number 3 was an F_1 from a Black Laced Red Cornish x White Cornish cross. He was mated with two Black Laced Red dams which were full sisters. They were from a Black Laced White Cornish x Dark Cornish mating. From the ratio of homochromatic to dichromatic progeny (34:11), both the sire and the dams were heterozygous Hc hc if the "Wx" progeny can be regarded as hen colored.

TABLE 1—Colors of sires and dams and distributions of progeny hatched in 1957

Mating number	1			2			3		
Sires	"Red Leghorn"			"W. L. R."			"W. L. R."		
Dams	x "W. L. R."			x "Red Leghorn"			x "B. L. R. Cornish"		
Color (*a*) of Progeny	No. M(*c*)	No. F(*d*)	Total	No. M	No. F	Total	No. M	No. F	Total
W.L.R.(*b*)	3	1	4	2	..	2	6	5	11
D.C.	2	..	2	1	1	2	5	6	11
P.R.(*b*)	2	2	4	4	1	5	4	1	5
w.t.R.(*b*)	2	2	4	4	4	8	4	4	8
Sil.N.R.(*b*)	1	..	1	..	..	..	..	..	..
b.l.r. and B.L.R.	..	1	1	..	..	..	2	3	5
Wx.(*b*)	..	..	..	..	..	..	..	3	3
Grey L.R.(*b*)	..	..	..	..	..	..	1	1	2
Totals	10	6	16	11	6	17	22	23	45

(*a*) Legend for Color Code:
W. L. R. = White Laced Red; D. C. = Dark Cornish hc; P. R. = Pea Combed Red; w. t. R. = White Tipped Red; Sil. N. R. = Silver Necked Red; b. l. r. = Indistinct Black Laced Red; B. L. R. = Distinct Black Laced Red; Wx = White with Black and/or Red Specks, not "Columbian"; Grey L. R. = Grey Laced Red.
Lower case letters = indistinct patterns or relatively less color.
(*b*) Hen colored phenotypes.
(*c*) M. = Males.
(*d*) F. = Females.

UNEXPECTED PHENOTYPES

From these matings, a number of unexpected and unorthodox phenotypes have appeared. The white of the "Silver Necked Red" from mating number 1, for instance, may be either "dominant white" or Silver. This phenotype occurs frequently from Silver x Dark Cornish matings but the white necked phenotype is also common in "White Laced Red Cornish" matings. The genotype of this particular individual must remain unknown since it has been eliminated from the flock. The genotypes of the other unorthodox specimens, i.e., the "Wx" and the Grey Laced Red, were undetermined also.

Interpretation of Results—Two Assumptions Possible

Two theoretical ratios could be tested from the data by means of the Chi-square test.

In matings number 1 and 2, it could be assumed, from appearances, that both parental phenotypes were homozygous for the Hc gene.

From the progeny data, such an assumption is not tenable for two or more hc individuals are apparent among the progeny of each mating. The alternative is to determine, by the Chi-square test, whether or not the distributions depart significantly from a characteristic 3:1 ratio. Such a ratio of "dominant" to recessive phenotypes among F_2 progeny is commonly accepted as evidence of dominance. The results of the computation were a Chi-square value of (1.25) from mating number 1 and (1.59) from mating number 2. Neither of these Chi-square values indicates a significant departure from an expected 3:1 ratio.

The progeny of mating number 3 yielded somewhat more conclusive evidence. Forty-five chicks were hatched from this mating. They were distributed as follows with respect to hen coloring—34 Hc:11 hc. A Chi-square value (.0064) indicates that the distribution does not depart significantly from an expected 3:1 ratio.

None of the male parents of progeny were morphologically "hen feathered".

SUMMARY AND ABSTRACT

Recorded color distributions of 78 F_2 phenotypes pertinent to the inheritance of hen coloring gene Hc were tabulated and analyzed statistically. The results confirm the postulation of either dominance or epistasis of the Hc gene. The parental phenotypes were M. S. U. bred and pedigreed strains of Red Leghorns[4] and White Laced Red Cornish.[4] Three types of single male matings were made: (1) Red Leghorn[4] x White Laced Red,[4] (2) White Laced Red x Red Leghorn, and (3) White Laced Red Cornish x Black Laced Red Cornish[4].

Most conclusive evidence was obtained from 45 progeny of mating number 3. They were distributed as follows with respect to hen coloring—34 Hc:11 hc. A Chi-square value of .0064 indicates an insignificant departure from an expected 3:1 ratio of dominant to recessive phenotypes.

[4]Hen colored phenotype.

INFLUENCE OF 2, 4-DICHLORPHENOXYACETIC ACID TREATMENT OF ZINNIA ON THE ABILITY TO RECOVER TOBACCO RINGSPOT VIRUS

By D. J. deZEEUW, J. G. KARAS and C. L. HAMNER[1]

INTRODUCTION

RESEMBLANCE BETWEEN the effects of growth regulators and viruses on plants has been noted at least since 1946 (2). In unpublished research at Michigan State University, some of the similarities of 2, 4-D treatment of zinnia have been compared to infection with tobacco ringspot virus (TRSV). In respect to chlorosis and stunting, the symptoms are often similar. In other respects, such as leaf malformation and progressive severity of symptoms, the 2, 4-D and TRSV are dissimilar. Combination treatment with virus and the auxin retarded growth more than either of them alone.

Johnson (4) characterized the response of zinnia to alpha-naphthoxyacetic acid, beta-naphtoxyacetic acid, and phenoxyacetic acid as a fusion of the leaves and of the central tips. The characteristic response of other species to growth regulators is determined by concentration, formulation and environmental conditions.

Various authors (5, 8, 9) described the response of zinnia to TRSV as combinations of mottle, chlorosis, interveinal puckering, leaf reflexing and stunting. Zinnia varieties differ in tolerance to TRSV (5).

Zinnia displays some of the typical aspects of TRSV infection of other plants. From the first to the fifth day after inoculation, the symptoms become increasingly severe. After the sixth day, there is a gradual reduction in intensity of most symptoms. Some reduction of size remains permanently, but chlorosis becomes less apparent until the plants become nearly symptomless (5).

[1] Departments of botany and plant pathology and horticulture respectively.

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Recovery studies on the virus in plants treated with 2, 4-D and infected with virus were begun to obtain some evidence on multiplication and movement of the virus and to determine any of the more basic similarities.

MATERIALS AND METHODS

Seed of certain varieties of *Zinnia elegans* and *Z. haageana* were sown in clay germination pots, transplanted in the seedlings stage into 3- or 4-inch clay pots filled with sand-soil-peat mixture, and grown at approximately 70° F. in the greenhouse.

The zinnia plants to be inoculated with the virus were selected at the 4-6 leaf stage. A mixture of infectious sap of stock culture tobacco plants and fine carborundum was sprayed under pressure at a distance of 1 inch onto the zinnia leaves. The carborundum acted as an abrasive and allowed the virus to penetrate the leaf epidermis. The methods have also been used in previous work (5).

The growth regulator was applied with a flysprayer until the solution dripped from the leaves. Plants treated thus formed new leaves above the treated area and these were sampled subsequently for the assays.

A variety of cowpea, designated "S", has utility for the assay of TRSV (1, 5). To determine the presence of the virus and its relative concentration in infected zinnia, a small part of the new growth formed after treatment was ground, mixed with carborundum, and carefully rubbed on primary leaves of the cowpea. Within 4 or 5 days, the virus produced chocolate to red-brown spots in numbers approximately proportional to the virus concentration in the zinnia from which the inoculum was taken.

RESULTS AND DISCUSSION

Four small scale experiments gave evidence that TRSV was suppressed by applications of 1, 5, 10 or 100 p.p.m. of 2,4-D (Table 1). The number of aberrant assays is indicated by a fraction numerator, while the plants assayed is the denominator. Where non-inoculated plants were assayed, an aberrant value would show an accidental infection. Aberrants in the inoculated series could be the result of incomplete inoculation, suppression of virus multiplication by the growth regulator, or assay on the wrong part of the plant. All the assays in these trials were made on new leaves that developed above the parts in-

oculated. None were made on inoculated leaves or older parts of the plants to determine if the change in translocation direction was responsible for the virus reduction.

TABLE 1—Recovery of TRSV from zinnia plants variously treated with the virus, 2,4-D and combination of TRSV and 2,4-D

	Control		Inoculated 1-3 days before:(c)			
Exp.	Not inoculated	Inoculated	2,4-D 1 p.p.m.	2,4-D 5 p.p.m.	2,4-D 10 p.p.m.	2,4-D 100 p.p.m.
1(a).....	0/12 (b)	0/12(c)	....	....	1/11	6/10
2.....	0/4	1/12	0/12	....	3/12	5/12
3.....	0/9	0/9	1/9	2/9	....	....
4.....	0/18	3/18	....	....	5/18	7/18
	0/43	4/51	1/21	2/9	9/41	18/40

(a) Varieties of zinnia used: Experiments 1-3: *Z. elegans* unknown yellow variety. Experiment 4: 6 varieties of *Z. elegans* and *Z. haageana*.
(b) Numerator indicates aberrant assay—virus infection in non-inoculated plants.
(c) Numerator indicates aberrant assay—virus not demonstrated in the inoculated plants. Denominator indicates the number of plants assayed in each case.

A more extensive assay was made in conjunction with an experiment on the physiology of combined treatments. Four 60-plant replications on uninoculated, TRSV, 2,4-D (10 p.p.m.) and the combination TRSV,2,4-D treatments were used to assay new growth 14 days after inoculation and treatment (Table 2). None of the controls or 2,4-D treated plants assayed virus presence. One of the inoculated plants appeared to have escaped infection. Only in the case of the combination treatment were there statistically significant

TABLE 2—Recovery of TRSV from blaze zinnia treated with 2,4-D 1 hour after inoculation with the virus

	Percent aberrant assays per plot	Significance(a)
Control—not inoculated .	0.0	N.S.
2,4-D 10 p.p.m.....	0.0	N.S.
Inoculated TRSV.....	1.7	N.S.
TRSV plus 2,4-D.....	13.3	**

(a) 60 plants, 4 replications.
** Significant at 1% level.

numbers of aberrants, i.e., plants failing to assay for virus in the new growth.

Certain of the evidence obtained points to an inhibition of virus multiplication such as Locke (7) seems to have found with 2,4-D against potato leaf roll. He found that high concentrations of 2,4-D prevented symptom expression for extended periods and even affected development of symptoms in subsequent grafts. We have observed, however, that the zinnias treated with both TRSV and 2,4-D were noticeably shorter than with either treatment alone. Gondo (3) reported that prior application of alpha NAA at 50 p.p.m. inhibited infection by Tobacco Mosaic Virus (TMV) up to 96 hours. Infection of zinnia by TRSV was accomplished an hour or more before application of 2,4-D in the present work and there can have been little direct effect of the growth regulator on the infection process itself. A more likely explanation is that the virus may have been directed to other parts of the plant than the terminal meristem. Limberk (6) showed that a simultaneous application of TMV with heteroauxin on tobacco caused the virus symptoms to appear in basal shoots; whereas normally the movement of the virus would be upward. Multiplication would not necessarily be completed inhibited if translocative changes prevented its movement upward for a time.

Further assays on other parts of the zinnia will be required before more definite conclusions can be drawn on 2,4-D inhibition of TRSV multiplication. Our observations indicate that translocation changes may be at least partly responsible since the combination treated plants are uniformly smaller than those treated with only the virus or the 2,4-D alone. Some of the mechanisms of this inhibition are being studied currently.

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THE EFFECT OF SALINITY UPON THE GROWTH OF CONTAINER-GROWN GREENHOUSE ROSES

By W. W. McCall,[1] R. F. STINSON[2] and R. S. LINDSTROM[2]

THE ROSE is the most important crop grown in Michigan greenhouses (8). An important problem in the production of this crop is the salinity of the soil.

Merkle and Dunkle (4) found that more than 20 percent of greenhouse soils tested by them contained excessive salts. McCall et al. (5) found that 65 percent of greenhouse soils tested over a period of a year in Michigan contained excessive salts and that another 8 percent were within the danger area for many sensitive plants. Richards (6) found that special cases of salinity occurred in greenhouses in humid as well as arid climates. He stated that irrigation with saline waters is often a contributing cause of salinity in the greenhouse. Baker (1) points out that salinity conditions in the greenhouse may be caused by fertilizer, water, or soil. Krone and Weinard (3) stated that well water frequently contains 100 p.p.m. or more of NaCl and that any water containing a total of 500 p.p.m. or more will probably be injurious to greenhouse plants. Hayward et al. (2) observed that although plant growth is reduced as the electrical conductivity of the soil solution increases, the extent of reduction in growth differs and must be determined for each plant.

Smith and Warren (7) found that all salts except the sulfates caused damage to tomatoes and lettuce at 200 x 10^{-5} mhos.

Much of the water used for irrigating in Michigan contains NaCl. The study reported here was undertaken to determine at what conductivity level of the watering solution, as affected by the NaCl content, would affect the growth of greenhouse-grown roses.

[1] Assistant professor, department of soil science, Mich. State. Univ.
[2] Associate and assistant professors, respectively, department of horticulture, Mich. State Univ.

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PROCEDURE

Cuttings of the greenhouse rose variety, "Better Times," were rooted in sand. The rooted cuttings were potted in 4-inch pots containing a mixture of 2 parts Conover loam, 1 part German peat and 1 part sharp sand.

After sufficient growth was obtained, the plants were transferred to 2-gallon glazed crocks filled with the same soil mixture and with bottom drainage. The soil mixture was leached thoroughly with distilled water; samples were taken, thoroughly dried, and the conductivity determined by use of the 1-2 soil-water extract. The young plants were placed in the crocks April 25, 1956 and the experiment was started on May 1, 1956. Five treatments, all of which were replicated five times, were applied as shown in Table 1. The proper solution was applied as the only source of moisture at the rate of 1 liter per application to completely saturate the soil volume. Soil samples were taken at 2-week intervals and the soil conductivity determined by using the 1-2 soil-water extract and a Model RD-15 Solubridge produced by Industrial Instruments, Cedar Grove, New Jersey.

The effect of soil salinity upon the growth of the rose plants was determined by both visual symptoms and by dry weights of the above-ground portion of the plants. Significance of the results was determined by analysis of variance.

TABLE 1—Treatments applied to greenhouse roses

Treatment No.	Grams per liter salt added		Conductivity of solution (mhos x 10^{-5})
	15-30-15 fertilizer	Sodium chloride	
1.....	.00	.00	0(*a*)
2.....	.45	.00	50
3.....	.45	.25	100
4.....	.45	.50	150
5.....	.45	.75	200

(*a*) Distilled water.

RESULTS AND DISCUSSION

The amounts of the salts added to the soil in each treatment are given in Table 2. Table 3 shows the effect of these salts upon the

TABLE 2—Total amount of salts added to each container during experiment

Time	Treatment number									
	1		2		3		4		5	
	Fert.	NaCl	Fert.	NaCl	Fert.	NaCl	Fert.	NaCl	Fert.	NaCl
weeks	gms.	gms.	gms.	gms.	gms.	gms.	gms.	gms.	gms.	gms.
2	0	0	1.8	0	1.8	1.0	1.8	3.2	1.8	5.4
4	0	0	3.6	0	3.6	2.0	3.6	6.4	3.6	10.8
6	0	0	4.5	0	4.5	2.5	4.5	8.0	4.5	13.5
8	0	0	7.2	0	7.2	4.0	7.2	12.8	7.2	21.6
11	0	0	9.9	0	9.9	5.5	9.9	17.6	9.9	29.7
14	0	0	12.6	0	12.6	7.0	12.6	22.4	12.6	37.8
16	0	0	14.4	0	14.4	8.0	14.4	25.6	14.4	43.2
18	0	0	16.2	0	16.2	9.0	16.2	28.8	16.2	48.6

salinity of each soil. The salinity increased sharply during the first 5 weeks and then leveled off, indicating that the soils had reached their approximate maximum saturation for salts at that time. The decrease in salinity levels during the last 4 weeks of the experiment are attributed to a decrease in the quantity of solution necessary to maintain plant needs, and the removal of some of the salts by the plants. The data in Table 3 show that generally the more salt added to the soil, the greater the salinity level developed in that soil. Usually, when applied salts contain plant nutrients, such as in a 15-30-15 fertilizer, salinity levels do not become as high as when non-nutritive salts,

TABLE 3—The average(a) conductivity(b) of the soil in each treatment

Time	Treatment number				
	1	2	3	4	5
weeks					
2	25.2	30.0	38.8	63.0	76.8
4	15.7	30.6	42.7	79.9	97.1
6	21.0	44.8	59.6	124.4	151.3
8	20.0	46.0	63.5	123.0	165.8
11	22.7	44.8	72.5	133.4	173.7
14	25.4	49.2	73.2	130.4	163.5
16	30.6	50.0	91.9	114.8	139.4
18	12.3	41.0	91.1	110.3	119.8

(*a*) Average of 5 replications.
(*b*) mhos x 10^{-5} determined on 1:2 soil-water extract.

such as the NaCl are used. This is due to the removal of the plant nutrient ions from the soil by plants and an accumulation of non-nutritive ions in the soil. The data support these observations.

The increasing levels of salinity in the soil reduced the yields of the roses (Fig. 1). The data indicate that the fertilizer solution promoted the greatest amount of growth of the roses. All treatments containing NaCl reduced the yields below that of the fertilizer solution. The lowest level of NaCl did not result in a statistically lower yield. However, the two higher levels did bring about yields significantly lower at the 1 percent level.

The appearance of the plants showed the effects of treatment from an early stage of growth. The "no salt" treatment produced typical nutrient deficiency symptoms for nitrogen, phosphorus and potassium (Fig. 2A). This deficiency accounts for the low yield with this treatment. However, adding the fertilizer solution alone promoted the

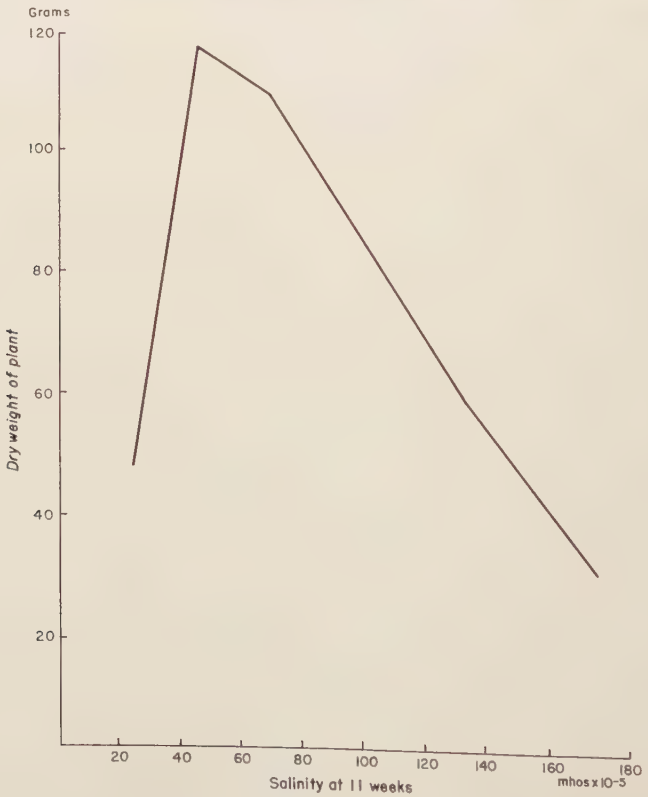

Fig. 1. The growth of rose plants as affected by the salinity of the soil.

growth of strong, healthy and vigorous plants which showed no signs of nutrient deficiency nor salt toxicity. Including the lowest amount of NaCl used in the treatments reduced plant vigor and yields. None of these plants exhibited nutrient deficiency and only a few exhibited symptoms of salt toxicity and this was not prominent. At the salinity level (90 mhos x 10^{-5}) of this treatment, few visual symptoms were evident, yet the plants were reduced in yield. This is the most dangerous level of salinity in the soil as it is difficult to diagnose without the use of a soil test. Many growers, observing this condition, feel that the slow growth and loss in vigor is due to insufficient nutrients, so they add more fertilizer and thus aggravate the problem.

The application of the second highest level of NaCl caused greatly reduced yields. No plants showed nutrient deficiency, but all exhibited severe symptoms of salt toxicity (Fig. 2B). At the highest levels of NaCl most of the plants died. Those that survived were severely damaged. It was noted that in all cases where the conductivity of the soil was 150 mhos x 10^{-5} or higher, the rose plants died.

Fig. 2. Appearance of rose leaves grown under different treatments. A. Nutrient deficient roses. Note pale color and venation of the leaves due to deficiency of nitrogen, phosphorus and potassium. B. Salinity toxicity induced by sodium chloride. Note the tip and marginal chlorosis of the typical symptoms.

SUMMARY

1. "Better Times" roses were grown in the greenhouse to determine the effect of soil salinity upon their growth.

2. Salts were added to the soil in the form of solutions of a 15-30-15 fertilizer and NaCl in sufficient strengths to produce solution conductivity readings of 50, 100, 200 and 300 mhos x 10^{-5}, respectively. A distilled water treatment was included as a check.

3. It was found that increasing levels of salt added to the soil increased the salinity of that soil as determined by a 1-2 soil-water extract.

4. Increasing salinity of the soil decreased the yield of roses as measured by the dry weight of the plants.

5. The data show that salinity levels of the soil for roses using a 1-2 soil-water extract may be interpreted as follows:

3- 30	mhos x 10^{-5}	deficient for growth
30- 50	"	optimum for growth
50-100	"	growth reduced but visual symptoms seldom shown
100-150	"	growth reduced, severe symptoms often shown
above-150	"	death usually results

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CHARACTERIZATION OF AN INDOLE TYPE COMPOUND SIMILAR TO INDOLE-3-ACETIC ACID FROM GOLDEN DELICIOUS APPLES

By A. L. KENWORTHY and NORMAN HARRIS

DEPARTMENT OF HORTICULTURE

AUXIN TYPE SUBSTANCES have been shown to occur in pollen of the apple (3), orchid (8), tobacco (5), and corn (7, 10, 14). Luckwill and Powell (4) reported an auxin (**Malus** auxin No. 2) in the flesh of apples that differed in physicochemical properties from indoleacetic acid (IAA) and had an Rf value approximately ½ that of authentic IAA. Our studies indicate that IAA may also be present in the flesh and skin of some varieties of apple.

Longitudinal slices (407 grams) of the skin and flesh (excluding the core) of mature Golden Delicious apples from Wenatchee Valley, Washington, were blended for 3 minutes in a Waring blender until a smooth slurry was obtained. This mixture was filtered at 0° C. through Whatman No. 12 folded filter paper. The filtrate obtained (73 ml.) was heated on a steam bath for 20 minutes to inactivate enzymes.

A 12 ml. aliquot of the filtrate was fractionated on a large, 200-gram silicic acid column using the method of Wise (13) and run according to the procedures of Marvel and Rands (6), and Buch *et al.* (1). The effluent fractions were titrated with .0153 *N* NaOH to determine where the peaks of acids were appearing. In one of the organic acid fractions—(fractions 86-91)—a slightly yellow colored product appeared. This eluate had a combined value of .0043 milliequivalents of acid per 12 ml. of filtrate. Fractions (86 through 91) were combined and concentrated to 2 ml. *in vacuo* at 30° C. A brown-colored residue was left that was insoluble in water and chloroform, but readily soluble in alcohol. A positive test with ferric chloride was obtained suggesting the presence of an aromatic compound. Ultra-

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violet light absorption spectra studies with a Beckman DK-2 spectrophotometer showed the substance to have a spectrum identical to IAA. A solution of the unknown in 95 percent ethanol absorbed light at wavelengths of 280 mμ and 290 mμ. This corresponded to the IAA absorption peak shown in figure 193 in a book by Friedel and Orchin (2). The unknown gave a negative ninhydrin test, thus excluding the possibility of the substance being tryptophan.

Ascending paper chromatography was used for further identification. The procedure of Palmer (9) was followed using a developing solvent of ether, 88 percent formic acid, and water in the proportions of 5:2:1. IAA had an Rf of .92 as did the unknown extract of the apple. When the unknown and IAA were mixed together, a single spot with an Rf of .92 was obtained. IAA and the unknown showed similar pink, turning to blue colors with Ehrlich's reagent.

To substantiate these findings, the authors used the method of Sen and Leopold (12) in which distilled water was used as the developing solvent. In addition, an authentic sample of the ethyl ester of indoleacetic acid was co-chromatographed using descending paper chromatography. The ethyl ester of IAA showed an Rf of .58 compared to the Rf of the unknown of .89; IAA had an Rf of .90. IAA and some of the apple unknown were co-chromatographed and an Rf of .88 was obtained. These spots gave a light purple color with Ehrlich's reagent.

Attempts to make the 1,3,5 trinitrobenzene adduct by the method of Redemann (11) were not successful.

Infrared spectroscopic studies showed that the functional groups of the unknown correspond to those of IAA (Table 1).

Bioassay of the unknown showed that the substance had growth promoting properties as determined by the tomato ovary test.

TABLE 1—Infrared absorption values of the functional groups of IAA and apple extract

Functional group	Wavelength (u)	
	IAA	Apple unknown
NH	2.94	2.95
Carboxyl OH	3.24—3.60	3.35—3.45
Carboxyl	5.88	6.09
Conjugated C = C of (o) phenyl	6.41—6.71	6.56—6.88
Orthodistributed (o) phenyl of indole	13.42	13.55

To the authors' knowledge, this is the first report of the characterization of a biologically active compound with physical, and chemical properties similar to IAA in the flesh and skin of the mature apple. Apparently, under certain environmental conditions the presence of IAA persists until the fruit is mature. Other samples and varieties of apples tested did not show the presence of IAA.

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EFFECT OF BLANCHING AND HOLDING TREATMENT ON THE QUALITY OF FRESH CUCUMBER PICKLES

By I. J. PFLUG and R. C. NICHOLAS

Department of Food Science

Fruits and vegetables are blanched to inactivate enzymes, reduce the microbiological population, further wash the product, set the color, soften tissue to improve fill and to aid in the removal of gases. The purpose of blanching in fresh pickle manufacture is somewhat obscure from a technical standpoint. Its use is confusing because of the wide range of practices in existence. Actual "blanching" practices range from no blanch to a treatment of several minutes in water (or steam) at 160-170°F. This wide range of treatments can be expected to have quite different effects on the quality of the finished product. This is particularly true during a pickle manufacturing operation since blanching is often followed by holding the cucumbers in a mild brine over a wide temperature range for varying lengths of time.

The objective of the study reported on here was to determine the influence of blanching and holding procedures on quality of fresh cucumber pickles. The study was designed to cover the range of manufacturing techniques that exist commercially in semi-continuous pickle manufacturing operations. In these it is necessary to accumulate and hold pickles for varying lengths of time after the sorting, washing and blanching operation but before packing the product in containers.

Experimental Procedure

Six bushels of No. 2 cucumbers (1-1 16 to 1-1 4 in. in diameter) of variety SMR15 from the same field were obtained from a local receiving station. The experimental pack was made approximately 24 hours after the cucumbers were harvested. The experiment was a complete factorial design: three blanching times - 0, 6, and 12 min.; three holding temperatures - 100, 120 and 140°F.; and three holding

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times - 1, 2 and 4 hours. The cucumbers were first washed and then randomly divided into lots and blanched. The blanching treatment was carried out in tap water controlled at 160°F. The blanching test lots were subdivided into further lots (each lot placed in a small cotton sack) and subjected to the holding treatments in 1 percent salt solutions controlled at 100, 120 and 140 F. After this 21 oz. of cucumbers from each treatment were hand packed into each of six quart jars. The jars were filled with 1.4 percent acid and 5.0 percent salt brine at room temperature and processed for 40 min. in a 180 F. water bath. The pickles were cooled immediately after pasteurization and stored at 70°F. in closed cases until examined.

A test (blanch vs. no-blanch, commercial) was also conducted where a dozen jars of fresh whole dill pickles were made by filling the jars by hand as the cucumbers discharged from the washer prior to blanching. A second dozen jars were hand packed with cucumbers from the packing table. These experiments were carried out in a commercial pickle manufacturing plant. The cucumbers had been subjected to the blanching and holding treatments used in normal production; the jars were coded, carried to the briner and placed on the conveyor so they all received the same brine, closure and pasteurization treatment. The jars were recovered as they came out of the pasteurizer, stored at 70°F. for 4 months and then pressure tested.

Analysis

Pressure, color and peroxidase enzyme activity were measured objectively. In addition, subjective observations were made regarding color and general quality. The mechanical recording pressure tester (5) was used to measure texture. Reflected color of skin and internal flesh was measured with a Gardner Automatic Color-Difference Meter. A Gardner white standard, $L = 90.9$, $a_L = -2.0$, $b_L = 2.5$, was used. The tabulated values are the ratio - $\frac{a_L}{b_L}$. Peroxidase activity was measured using Anderson's procedure (1).

Results

The average pressure of the raw product was 17.3 lb. The average pressures after blanching and holding as a function of treatment are listed in Table 1. An analysis of variance of the data in Table 1 indicated little or no effect of holding time on the product pressures.

TABLE 1—Average pressure(a) after blanching and holding (pressure in lbs., 5/16" plunger)

Holding time, hr.	Blanching time, min. 0			6			12		
	Holding temp. °F.			Holding temp. °F.			Holding temp. °F.		
	100	120	140	100	120	140	100	120	140
1.....	16.4	15.4	14.1	14.6	15.4	14.4	15.4	14.8	14.1
2.....	16.3	16.7	13.9	15.0	13.4	13.5	14.3	14.0	15.2
4.....	17.8	14.0	13.8	14.0	14.6	13.5	15.2	16.3	13.8

(a) of 10 cucumbers.

There were possible effects of blanching time: The no-blanch treatment showed the highest pressure while the 6-min. blanch showed lower pressure than the 12-min. blanch. The differences, however, were not significant at the 5 percent level. There was a decrease in pressure with increasing holding temperature that was significant at the 10 percent level.

The average pressures after processing are listed in Table 2. The outstanding result was the increase in pressure from an all treatment average of 12.0 lb. to 14.1 lb. (summary 2-way tables not shown) with increased blanching time from 0 to 12 min., which was significant at the 1 percent level. Neither holding time nor holding temperature had a significant effect (at 5 percent level) on pressure. The interaction

TABLE 2—Average pressure(a) after blanching, holding and processing (pressure in lbs., 5/16" plunger)

Holding time, hr.	Blanching time, min. 0			6			12		
	Holding temp. °F.			Holding temp. °F.			Holding temp. °F.		
	100	120	140	100	120	140	100	120	140
1.....	12.4	12.4	13.6	13.1	12.5	12.8	13.7	13.8	13.8
2.....	12.3	11.0	12.7	13.1	12.4	13.1	14.2	13.8	13.6
4.....	12.0	9.8	11.5	11.8	12.1	13.3	14.1	15.0	14.5

(a) of 20 pickles

between blanching time and holding time was significant at the 1 percent level; at 0 blanching time, pressure decreased with holding time; whereas, at 12-min. blanching time, pressure increased with holding time. The blanching time - holding temperature interaction was also significant at the 1 percent level.

The results of the enzyme analysis are listed in Table 3. While there are certainly no large differences in the enzyme results, the trends are as follows: There appears to be a decrease in enzyme activity with increasing holding temperature; there appears to be an increase in the enzyme activity with increased blanching time; and there appears to be a decrease in enzyme activity with increased holding time. It would normally be anticipated that increasing the holding temperature and increasing the holding time would decrease the enzyme activities. However, it would also normally be expected that an increase in blanching time would also decrease the enzyme activity. In this case, however, the reverse appears to be true regarding blanching time.

TABLE 3—Average(a) enzyme activity after blanching, holding and processing. Enzyme activity, units

Holding time, hr.	Blanching time, min.								
	0			6			12		
	Holding temp. °F.			Holding temp. °F.			Holding temp. °F.		
	100	120	140	100	120	140	100	120	140
1	4.0	4.5	3.5	4.2	3.8	4.0	5.5	4.2	4.8
2	3.9	4.9	3.9	5.1	5.5	3.5	4.5	3.5	3.5
4	3.5	3.5	3.5	5.1	5.2	5.0	5.2	4.1	3.5

(a) of 2 determinations, each from 2 jars.

The results of the average color as measured by the Gardner Color-Difference Meter are shown in Table 4. In general, these results (high numbers indicate more green color, low numbers a more yellow color), may be sumarized as follows: as the blanching time increased, there was an increase in green color; as the holding time increased, there was an increase in green color; and as holding temperature increased, there was also an increase in green color. It can be con-

cluded, therefore, that there is more green color retention with increased pre-pasteurization heating. (Colored slides of the finished pickles are available in department files).

In the no-blanch vs. commercial treatment tests, the no-blanch pickles had an average pressure of 12.5 lbs., ranging 8.3 to 16.2 lbs.; commercial treatment which included a blanch and hold had an average pressure of 8.5 lbs. with a range of 5.4 to 12.9 lbs. There were noticeable differences in the skin texture; the no-blanch pickles had a less tough skin and a more firm center.

TABLE 4—Color (a/b ratio) after blanching, holding and processing. Color ratio a/b

Holding time, hr.	Blanching time, min.								
	0			6			12		
	Holding temp. °F.			Holding temp. °F.			Holding temp. °F.		
	100	120	140	100	120	140	100	120	140
1.....	0.12	0.11	0.29	0.31	0.34	0.34	0.34	0.29	....
2.....	0.12	0.16	0.29	0.33	0.40	0.43	0.31	0.37	0.43
4.....	0.18	0.25	0.35	0.45	0.39	0.40	0.38	0.38	0.50

Discussion

The results indicate rather conclusively that if No. 2 sized pickles are to be held, they should receive a blanching treatment equivalent at least to 12 min. at 160°F. Since this experiment did not include sufficiently long blanching times to show a maximum, a future study will be undertaken to locate the optimum blanching time. Based on the results of the effect of heat on softening reported by Nicholas and Pflug (4), the maximum blanch would be less than 4 equivalent minutes at 180°F.

The significant softening evidenced in some of the treatments of this study is undoubtedly due to the activity of one or more of the pectin degrading enzymes naturally found in cucumbers (2 and 3). The increase in pressure with increased blanching time (after processing) is consistent with the theory that the changes being measured are enzyme-catalyzed, since more enzyme would have been destroyed

by the longer blanch. The effect of holding time and holding temperature in the 0 and 6 min. blanch treatment (Table 2) can be explained by normal enzyme behavior. Holding cucumbers at 140 F. for an hour or more would have an enzyme-inactivating effect, whereas holding at 120 F. may be near the optimum temperature for enzyme activity. If 120 F. is near the optimum, then less effect would be expected at 100°F.

The results of the peroxidase enzyme test (Table 3) are inconclusive, but not inconsistent. It appears obvious that peroxidase is not the enzyme involved in softening and since no other quality defects were observed, it must be concluded that the pasteurization treatment was adequate to reduce peroxidase to a sufficiently low level to prevent off flavor.

The increase in green color with increased blanch, holding time and holding temperature is similar to the results of a study of green color in pickles reported by Wheaten and Fabian (6). They observed that pickle slices receiving any of four blanching treatments, tested 1-5 minutes in boiling water, had a much better green color than those receiving no blanch.

The results of the blanch vs. no-blanch plant study would now be expected although it was quite a surprise at the time. The no-blanch treatment was also a no-hold treatment, and as such would produce a maximum pressure. The plant blanch was probably somewhere between 0 and 6 min. at 160°F., with a holding time of 2 to 4 hrs. at 100 to 120°F.

SUMMARY

The effect of three blanching treatments and nine post-blanching holding treatments on the quality of fresh whole pickles has been evaluated. The longest blanching time produced the firmest pickles. Holding times and holding temperatures did not individually produce a significant effect. However, holding time—blanching time and holding temperature—blanching time interaction were significant at the 1 percent level.

Blanching times in this experiment were not sufficiently long to determine the optimum blanching time for maximum firmness; however, the results indicate that holding unblanched or lightly blanched cucumbers in water or dilute brine at 100 or 120 F. for several hours is to be avoided.

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Acknowledgment

The authors wish to thank Professor C. L. Bedford, Mr. Thomas Mulvaney and Mr. Albert Saari of the Food Science Department and the H. W. Madison Company, Medina, Ohio, for their assistance in this study.

MOISTURE MIGRATION IN MIXTURES OF DAMP AND DRY SHELLED CORN

By W. H. SHELDON

DEPARTMENT OF AGRICULTURAL ENGINEERING

MIXING DAMP SHELLED CORN with other shelled corn, which is drier than necessary, is a method of removing excess moisture from damp corn without the expense of running it through a grain dryer. Mixtures of damp and dry shelled corn were studied at Michigan State University with three objectives in mind:

1. To determine approximate mixtures of damp and dry shelled corn that will have a mean moisture content of 15.5 percent.
2. To determine the time required for mixtures of damp and dry shelled corn to come to equilibrium in closed containers.
3. To verify the assumption that appropriate mixtures of damp and dry shelled corn may be stored without danger of molding.

PROCEDURE

The corn used in these tests was a yellow dent hybrid which had been stored at 40 F. for a period of 9 months. It had an average moisture content of 13 percent. A portion of this corn was wetted and allowed to stand in a sealed container for 1 week at 40°F. before starting the tests.

Samples of damp and dry corn were placed in sealed containers so that the moisture contents could equalize. For positive identification and ease of removal for frequent weighing, the damp samples were enclosed in open mesh bags made of cheesecloth (Fig. 1). The sample containers were stored at 40°, 60°, and 86°F. Four replicates were prepared for each temperature. The 40° samples were weighed within the 40° walk-in refrigerator box. The 60° and 86° samples were weighed outside of the controlled temperature boxes. At the end of the test period, all samples were oven dried and the dry weight of each sample was used as a basis for moisture content calculations.

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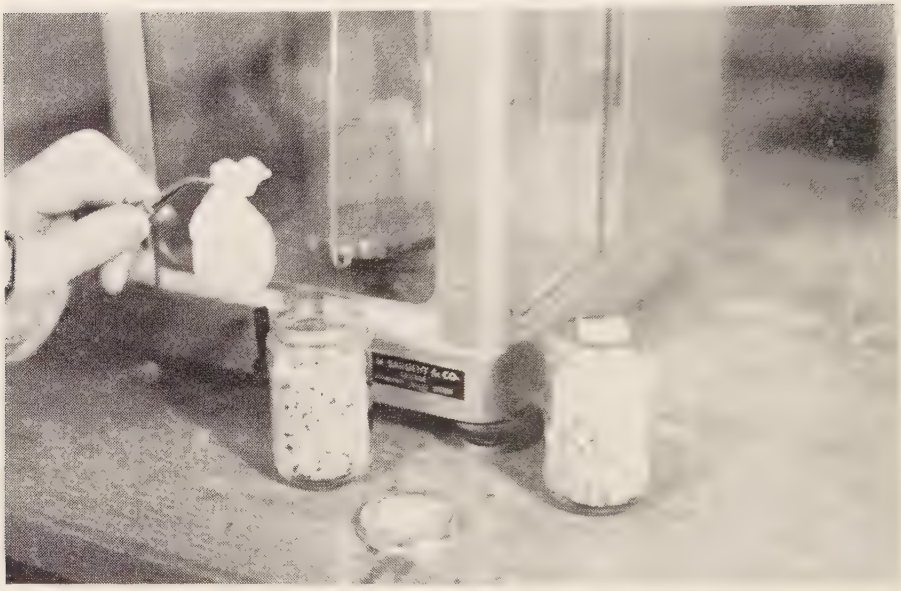

Fig. 1. A wet sample being removed from container for weighing.

RESULTS

Figure 2 shows the moisture content for damp samples in cheesecloth bags and loose dry samples together in sealed containers at each of the temperatures indicated. The movement of moisture was rapid at first with a progressively slower rate for the duration of the test period. The movement of moisture was most rapid with the highest temperature. The damp 86° samples lost twice as much moisture during the first 10 days as did the damp 40 samples during the same period. The difference in moisture movement rate between 60° and 40° samples was relatively small. Evidence of molding was not observed on any sample during the test period.

Table 1 shows the amount of dry corn to mix with damp corn so that the mean moisture content will be 15.5 percent.

DISCUSSION

Vapor pressure is recognized as the force that causes moisture to move from a damp location to a less damp location within the same material, or to other material where the vapor pressure is less. When hygroscopic material such as grain is placed in a closed container

with air at low humidity and allowed to stand, moisture moves from the grain into the air until a state of equilibrium is approached (1). If the humidity of the air is high and the moisture content of the grain is low, then moisture moves into the grain from the air until a state of equilibrium is approached. When damp grain is mixed with dry grain, the migration of moisture is from damp grain to air and from air to dry grain. Williamson (6) found that the relative humidity of the air within a mixture of damp wheat and dry wheat was in equilibrium with the mean moisture content of the mixture 3 minutes after the samples were mixed and remained constant as moisture migrated from the damp to the dry wheat. His wheat was within 1 percent of equilibrium within 4 days. This rapid migration of moisture in wheat can be attributed to the porous nature of the surface of wheat and the small size of the kernels. A kernel of corn is larger than wheat and has

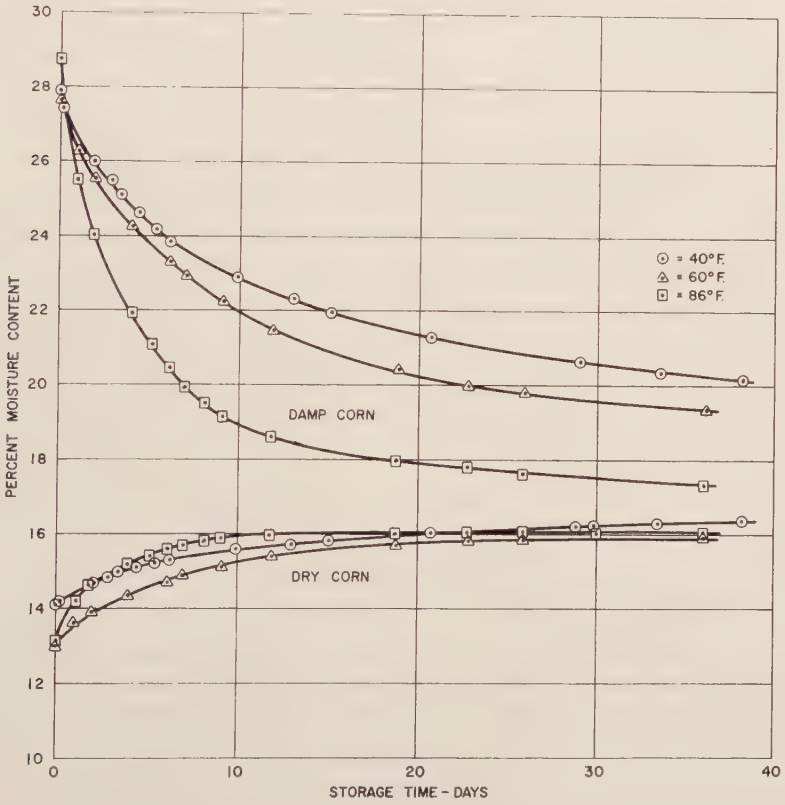

Fig. 2. Moisture content of damp and dry shelled corn when stored in closed containers.

a seed coat nearly impervious to moisture. Teter and Roane (4), with reference to data by Thompson and Shedd (5), state that a minimum wet bulb depression of 2.5 degrees is necessary in order that corn may be dried by air at 40°F. Henderson (3) discussed equilibrium moisture content as the approach of the moisture content in a product to a value controlled by ambient relative humidity and temperature. Figure 2 shows considerable difference in the moisture content of the damp and dry samples of corn even after 35 days.

Mold will develop on the surface of shelled corn when the temperature and humidity of the air in contact with the corn is favorable to mold growth (2). Shelled corn, therefore, will keep without molding, regardless of its internal moisture content, so long as the grain is in an environment unfavorable to mold growth. In these tests, there was no evidence of mold. The minimum distance from damp kernel to dry kernel was through a layer of cheesecloth and the maximum distance was 3 inches (the inside depth of the glass container). In normal practice, the average distance from damp to dry kernels would be less with uniform mixing, and in case of poor mixing, there could be a chance for hot spots and mold to develop. Aeration would be helpful in cooling spots which tend to heat due to poor mixing. Williamson (6) found that intermittent circulation of the inter-granular air did not

TABLE 1—Pounds of dry corn to add to 100 pounds of damp corn for a mean moisture content of 15.5 percent

Percent moisture content dry corn	Percent moisture content damp corn												
	16%	16.5	17.0	17.5	18.0	18.5	19.0	19.5	20.0	22	24	26	28
15.0	100 lb.	200	300	400	500	600	700	800	900	1300	1700	2100	2500
14.5	50.0	100	150	200	250	300	350	400	450	650	850	1050	1250
14.0	33.4	66.7	100	133	167	200	234	267	300	433	567	700	833
13.5	25.0	50.0	75.0	100	125	150	175	200	226	325	425	525	625
13.0	20.0	40.0	60.0	80.0	100	120	140	160	180	260	340	420	500
12.5	16.7	33.3	50.0	66.7	83.5	100	117	133	150	217	284	350	417
12.0	14.3	28.5	43.0	57.3	71.6	86.0	100	114	129	186	243	300	357
11.5	12.5	24.9	37.6	50.0	62.8	75.0	87.5	100	113	163	224	263	313
11.0	11.1	22.2	33.4	44.5	55.6	66.7	77.8	89.0	100	144	189	234	278

$$\text{Pounds of dry corn to add to 100 pounds of damp corn} = \frac{100 \text{ pounds of damp corn} \times (\%\ \text{MC} - 15.5\%)}{15.5\% - \text{MC of dry corn in percent}}$$

Note: This formula may be used for mixtures with any desired final moisture content by substituting the desired final moisture content, in percent, at both places where 15.5% appears in this formula.

improve the drying rate of damp wheat intimately mixed with suitable proportions of dry wheat.

SUMMARY

The time required for excess moisture in damp kernels of corn to migrate to dry kernels of corn within closed containers was determined for storage temperatures of 40°, 60°, and 86°F. The migration of moisture from damp corn was rapid during the first day and was progressively slower thereafter for the duration of these tests. The rate of moisture movement was highest with the highest storage temperature, but in no case did a damp sample and a dry sample stored together reach equilibrium during the 35-day test period. The samples did not show any signs of molding during the test period. This indicates that damp shelled corn is free from danger of molding when mixed with an appropriate amount of dry shelled corn.

CONCLUSIONS

1. When damp corn and dry corn are mixed, moisture migrates from the damp to the dry kernels. This moisture movement is rapid at first and continues at a progressively slower rate without reaching equilibrium during a period of 35 days.
2. Mixtures of damp and dry shelled corn, with a mean moisture content of 15.5 percent or less, are safe to put in storage because the relative humidity of air within the grain mass is not favorable for mold growth.

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THE WHOLESOMENESS OF IRRADIATED POTATOES FED TO RATS

By B. ELAINE RUTHERFORD, D. E. WIANT and D. R. ISLEIB

DEPARTMENTS OF FOODS AND NUTRITION, AGRICULTURAL ENGINEERING AND FARM CROPS

INTRODUCTION

IONIZING RADIATION inhibits sprout formation of potatoes, thereby increasing storage life.[1] The dose required for this is of the order of 10,000 rep.[2] This dose does not impair flavor or general acceptability of the potatoes. The possibility that chemical changes induced by radiation may affect the wholesomeness of the potato led to the investigation reported herein.

Burns et al.[3], in a long term study with rats, fed diets containing potatoes irradiated at 0, 15,000, and 30,000 rep with gamma rays. A vascular disease closely resembling periarteritis nordosa of man was observed in 56 percent of 52 first generation animals which died before the end of the experiment. The incidence of this condition did not seem to be influenced by radiation but was associated with heredity. These authors also reported a greater number of deaths from respiratory disease among animals fed irradiated diets, although the lesions of this disease were common in all groups. Therefore, further studies of the effects of the ingestion of irradiated potatoes seemed desirable.

The study presents results of feeding potatoes, irradiated with either cathode ray or gamma radiation, to rats for a period of 6 months.

The criteria used to investigate wholesomeness of the diets were:

1) Growth rate of the animals
2) Incidence of disease
3) Observations of internal organs at autopsy
4) Histopathological examination of tissues

[1] Brownell, L. E., F. G. Gustafson, J. V. Nehemias, D. R. Isleib, and W. J. Hooker (1957). Storage properties of gamma-irradiated potatoes. Food Technol. 6: 306-312.

[2] Rep. (roentgen equivalent physical) = the absorption of 93 ergs per gram of material.

[3] Burns, C. H., G. D. Abrams, and L. E. Brownell (1960). Growth, reproduction, mortality, and pathologic changes in rats fed gamma-irradiated potatoes. Toxicology and Applied Pharmacology 2: 111-131.

ARTICLE 44–13

EXPERIMENTAL PROCEDURE

Irradiation

Each of four lots of whole potatoes received doses of 10,000 or 20,000 rep[2] by one of two types of ionizing radiation: gamma radiation from a cobalt-60 source[4], or cathode rays from a one million electron volt electron beam generator (resonant transformer type)[5]. A fifth lot of potatoes, not irradiated, served as the control.

TABLE 1—Experimental diets formula

Ingredient	Percent
Dried potato	60
Casein	12
Lactalbumen	8
Corn oil	10
Vitamin mix(*a*)	2
Mineral mix(*b*)	4
Alphacel	4

(*a*) Vitamin diet fortification mixture, Nutritional Biochemicals Corp., Cleveland, Ohio.
(*b*) Wesson salts and salt mixture W, Nutritional Biochemicals Corp., Cleveland, Ohio.

EXPERIMENTAL DIETS

The five lots of whole, unpeeled potatoes were cooked by steaming for 30 minutes, riced, dried at a temperature of 110 F., and ground to a fine powder. The dried, ground potatoes were incorporated into animal diets at a level of 60 percent of the total diet. The complete diet formula is presented in Table 1.

ANIMAL EXPERIMENT

Fifty male and 50 female weanling albino rats[6], averaging 45 to 50 grams each, were assigned to the experimental diets so that each diet was received by 20 animals (10 male and 10 female).

The animals were housed in individual wire-bottom cages and were allowed food and water ad libitum for a period of 180 days. Records of daily food consumption and weekly body weight gains were kept for each animal.

[4] Phoenix laboratory, Univ. of Mich., Ann Arbor.
[5] Department of agricultural engineering, Mich. State Univ., East Lansing.
[6] Holtzman strain, Madison, Wisc.

At the end of the 6-month feeding period, the rats were killed with chloroform, gross autopsies performed, and weights of five internal organs (heart, lungs, kidneys, liver, and spleen) recorded. Sections of 11 tissues (heart, lung, aorta, vena cava, liver, spleen, kidney, stomach, small intestine, and colon) were fixed in formalin and subsequently embedded in paraffin blocks.

A complete set of tissues from four animals (two male and two female) was selected at random from each diet group for histopathological examination. Routine hematoxylin and eosin slides were prepared of the tissues in each of the 20 sets of paraffin blocks, and were examined microscopically for possible pathological conditions.[7]

RESULTS AND DISCUSSION

During the 6-month feeding period, gross pathological observations indicated no abnormalities that could be associated with a particular diet. Moderate respiratory disturbances were noted in nine animals, but this is a common finding in albino rats and the incidence was as great among animals on the control diet as those fed irradiated feed. One animal (female, 10,000 rep gamma-irradiated diet) died during the final week of the experiment, from severe respiratory infection.

Figures 1 and 2 show the growth curves of animals fed cathode ray- and gamma ray-irradiated potatoes, respectively, for the entire 6-month feeding period. During the initial period of rapid growth (first 5 weeks), no differences among diet groups were apparent. This observation was substantiated by analysis of variance of feed efficiencies (gain in body weight per unit weight of food eaten), which indicated no significant differences due to ingestion of irradiated potatoes. A tendency to higher average body weights of both male and female groups fed 10,000 rep cathode- 10,000 and 20,000 rep gamma irradiated potatoes during the latter part of the experiment is due to a higher average food intake of these groups (Table 2).

Autopsies at the termination of the feeding trial indicated no abnormalities that could be attributed to any one diet treatment. Gross examination of the arteries of the gastro-intestinal tract failed to reveal the necrotizing arteritis described by Burns.

The weights of internal organs obtained at autopsy are presented in Table 3 and are expressed as weight in grams per gram live body

[7] Hazleton Laboratories Inc., Falls Church, Va.

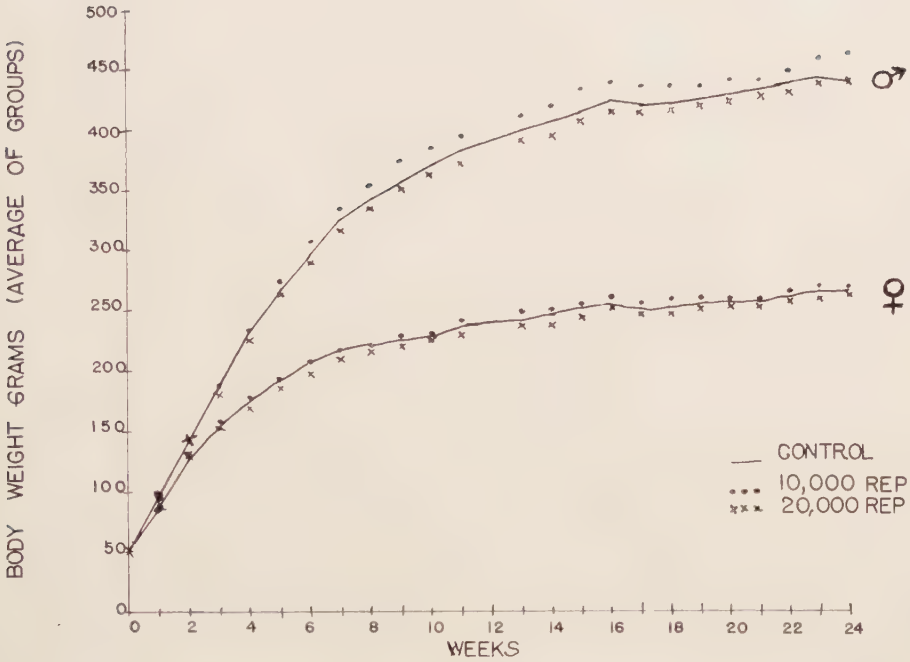

Fig. 1. Growth curves of rats fed cathode ray-irradiated potatoes.

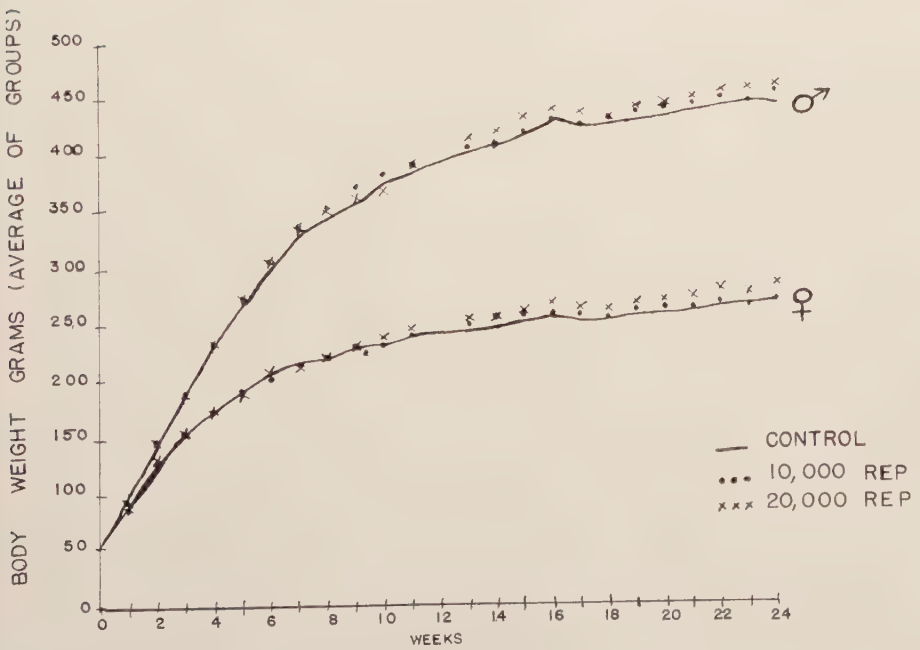

Fig. 2. Growth curves of rats fed gamma-irradiated potatoes.

TABLE 2—Average weekly food intake of diet groups after 13 weeks

Diet	Males (♂)	Female (♀)
	(grams)	(grams)
Control	130	94
10,000 rep cathode	135	94
20,000 rep cathode	125	93
10,000 rep gamma	132	97
20,000 rep gamma	135	101

weight. Analysis of variance of these data showed no significant differences due to type or level of radiation treatment of diets.

Thus, the ingestion of irradiated potatoes for a period of 6 months had no measurable effect on the rate of growth or the size of the internal organs of rats, as compared with the ingestion of unirradiated potatoes for the same period of time.

Histopathological examination of 11 tissues, previously listed, showed that these tissues were essentially normal (Table 4). The frequency of observations of deviations from normal was as high among animals fed the control diet as among those fed irradiated diets. The generally negative findings in this representative sample made it unnecessary to submit the tissues from the remainder of the animals for examination.

TABLE 3—Organ weights (grams per unit body weight) average of diet groups

Diet		Liver	Spleen	Kidneys	Lungs	Heart
Control	(♂)	3.58 ± 0.13 (*a*)	0.187 ± 0.008	0.386 ± 0.014	0.529 ± 0.037	0.372 ± 0.010
	(♀)	4.03 ± 0.14	0.223 ± 0.006	0.435 ± 0.013	0.612 ± 0.012	0.434 ± 0.011
10,000 rep cathode	(♂)	3.41 ± 0.08	0.182 ± 0.010	0.360 ± 0.010	0.457 ± 0.014	0.348 ± 0.011
	(♀)	3.71 ± 0.12	0.236 ± 0.010	0.430 ± 0.009	0.600 ± 0.017	0.426 ± 0.011
10,000 rep gamma	(♂)	3.37 ± 0.09	0.173 ± 0.007	0.388 ± 0.010	0.465 ± 0.018	0.358 ± 0.010
	(♀)	3.69 ± 0.15	0.205 ± 0.007	0.414 ± 0.007	0.597 ± 0.026	0.417 ± 0.015
20,000 rep cathode	(♂)	3.83 ± 0.16	0.185 ± 0.006	0.409 ± 0.010	0.591 ± 0.070	0.384 ± 0.051
	(♀)	3.80 ± 0.12	0.252 ± 0.018	0.439 ± 0.020	0.669 ± 0.070	0.552 ± 0.141
20,000 rep gamma	(♂)	3.42 ± 0.11	0.183 ± 0.007	0.384 ± 0.009	0.479 ± 0.016	0.350 ± 0.003
	(♀)	3.86 ± 0.10	0.215 ± 0.007	0.399 ± 0.022	0.598 ± 0.013	0.414 ± 0.008
L.S.D.(diets)		N.S.	N.S.	N.S.	N.S.	N.S.

(*a*) Standard error of the mean.

TABLE 4—Summary of histopathological findings of 11 tissues from 20 animals

LUNG	17 of the 20 sections were within normal limits. 3 of the 20 sections showed slight to moderate lymphoid hyperplasia associated with peribronchial tissue. This is a common finding and often associated with chronic murine pneumonia.
HEART	All 20 sections were within normal limits.
AORTA	All 20 sections were within normal limits.
VENA CAVA	All 20 sections were within normal limits.
LIVER	9 of the 20 sections were within normal limits. 11 of the 20 sections showed slight to moderate fatty metamorphosis of the hepatic cells. This is not uncommon in animals fed high carbohydrate diets.
SPLEEN	All 20 sections showed slight to marked pigment deposition but were within normal limits otherwise. Pigmentation of the spleen is common in the albino rat.
KIDNEY	9 of the 20 sections were within normal limits. 11 of the 20 sections showed a few renal tubule casts or were mildly to moderately congested. These were within normal limits otherwise.
STOMACH	All 20 sections were within normal limits.
SMALL INTESTINE	All 20 sections were within normal limits.
COLON	All 20 sections were within normal limits.

SUMMARY AND CONCLUSIONS

Potatoes irradiated at 10,000 and 20,000 rep with cathode rays, and 10,000 and 20,000 rep gamma rays were fed as 60 percent of the total diet to albino rats for a period of 6 months. A comparable diet containing non-irradiated potatoes served as control. Each of the five diets was fed to 20 animals. Incidence of disease among all animals was normal and autopsies at the termination of the experiment showed no abnormalities that could be associated with any one diet treatment. Statistical analysis (analysis of variance) of food efficiencies, and internal organ weights (heart, kidneys, lungs, liver, and spleen), showed no significant differences with regard to type or level of irradiation. Histopathological examination of 11 tissues (lungs, heart, aorta, vena cava, liver, spleen, kidneys, stomach, small intestine, and colon) of four animals in each diet group, indicated no apparent effect on the tissues as a result of the ingestion of irradiated potatoes.

It would appear from the results of this study that the wholesomeness of potatoes for rats, as judged by a feeding trial of 6 months, is not affected by irradiation with either cathode or gamma rays in dosages up to 20,000 rep.

CHANGES IN FOOD BUYING KNOWLEDGE IN FOUR CITIES SERVED BY CONSUMER MARKETING INFORMATION AGENTS

By JAMES D. SHAFFER and MARY S. HOLMES

Department of Agricultural Economics

This study was based on a short quiz conducted by mail in 1957 and again in 1959. The 1957 survey served as a bench mark for measuring change in certain areas of food buying knowledge.[1] The subjects of the quiz questions were to be included in the newspaper releases, radio, and television programs, and general on-going programs of the Consumer Marketing Information agents in Michigan during the 2 intervening years.

The purpose of the study was to measure change in consumers' knowledge of food buying after being exposed to the Marketing Information for Consumers Program. The study also attempted to measure change in the attitude of homemakers toward food marketing information and their awareness of the Consumer Marketing Information Program.

The Questionnaire and Sample

The questionnaire consisted primarily of statements to which the respondents were asked to check one of three responses—agree, disagree or no opinion. Some of the statements were simply matters of opinion, but many could be scored as correct or incorrect. The quiz contained questions concerning eggs, meat, beef grades, reconstituted nonfat dry milk, apple grades and general food costs. Questions concerning the socio-economic characteristics of the family and its acquaintanceship with the Marketing Information for Consumers Program were also included in the survey.

[1] Results of the 1957 survey are reported in detail in an M.S. thesis by Mary Strickland Holmes (1958). Some indications of level of knowledge and opinions of Michigan homemakers about food buying, Mich. State Univ. and reported in summary in, Some indications of homemakers' knowledge about food buying and attitudes toward food buying information, Mich. Agr. Expt. Sta. Quart. Bul. 41: 41-70, by Mary Strickland Holmes and James D. Shaffer (1959).

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The surveys were done by mail, using identical questions in 1957 and 1959. The samples for both years were drawn systematically from the address sections of the city directories of Muskegon, Flint, Grand Rapids, and Kalamazoo. One thousand residential addresses were selected from each city for each of the two years, a total of 8,000 addresses. The 1959 survey did not include the same families surveyed in 1957. Rather, the 1959 sample consisted of neighbors of the 1957 respondents. In both years, the rate of response was about 50 percent, after adjusting for vacant addresses. Two reminder letters were used each year. The questionnaires were sent from and returned to Michigan State University. There was no indication of any relationship of the study to the Consumers Marketing Information agents.

Along with including the general topics in their programs, the Consumer Marketing Information agents were asked to give special emphasis to 12 selected questions 6 months prior to the second mailings.

There was no Consumer Marketing Information agent in Muskegon during most of the 2 years between the surveys, although mass media coverage from Grand Rapids, Kalamazoo, and Detroit extends to Muskegon to some extent.

Change in Knowledge in Total Sample

A comparison of the responses for the total sample of the five cities combined between 1957 and 1959 is shown in Table 1 for each of the 24 questions tested. Those questions showing a statistically significant difference are indicated, as are those 12 questions receiving special emphasis in the Information Program.

As the table shows, eight of the 24 questions tested indicate a statistically significant difference in rate of response from 1957 to 1959. Five of these were from the 12 questions that were given special emphasis. In all cases, a larger percentage of the homemakers answered these eight questions correctly in 1959 than in 1957.

Change in Knowledge in Individual Cities

Table 2 shows changes in percent giving correct response for those questions showing a statistically significant[2] increase in correct response for each city.[3] Data are given in the table only for those

[2] With the t test at the 5 percent level of significance.

[3] In each case where a significant difference was found, the change was to a higher percentage of correct responses in 1959.

TABLE 1—Comparison of responses to information questions between 1957 and 1959 for combined total sample of the four cities

No.	Question	Percent of correct answers	
		1957	1959
11	White eggs are better quality than brown eggs	77	76
13(*a*)	Small eggs are usually less expensive per pound than large eggs during September	46	53*
14	To meet the standards for Grade A eggs, they must be large and all white	66	68
15(*a*)	Grade B eggs are suitable for cooking	67	69
16	The lower grades of beef do not have quite as much nutritional value as do the higher grades	74	71
17(*a*)	The larger the percentage of the center section of a whole pork loin that is included in a pork roast, the more desirable it will be.	68	71*
18	A fresh Boston Butt @ 49¢ a pound will give you more lean pork per dollar than a fresh picnic shoulder at 39¢ per pound	41	44
19(*a*)	The amount of edible meat per pound is usually greater for a Butt portion than for the Butt half of ham of equal quality	25	26
20	Most people would find that ham labeled "ready to eat" is cooked enough to eat without further cooking	58	64*
21(*a*)	The fat around the edge of beef is known as the marbling	43	52*
22	There is usually more difference in price between the chuck roast and steak in the summer than in the fall and winter months	40	39
23(*a*)	A higher grade is more important when choosing steak than when choosing chuck roast	70	69
25	(Non-fat dry milk) It has only about half the number of calories per glass as fluid whole milk	50	55*
26(*a*)	(Non-fat dry milk) It costs about 1/3 as much as fluid whole milk.	64	66
27	(Non-fat dry milk) It has all the vitamins and minerals that are in fluid whole milk except Vitamin A	34	35
29(*a*)	The higher the grade of beef the less fat it will have	68	70
30	Meat Graded U. S. Choice is a higher Grade than U. S. Commercial	52	52
31(*a*)	Meat Graded U. S. Choice is a higher Grade than U. S. Prime	53	56
32	All meat stamped "U.S. Inspected and Passed" has been graded by the U. S. Government	13	14
33	You can usually expect more marbling in a higher grade of beef.	54	58*
34(*a*)	The Delicious variety of apple makes better pies than the MacIntosh variety	80	83*
37	The only difference between "U.S. 1" and "U.S. Fancy" is the color of the apple	12	12
38(*a*)	The average American worker is spending about the same percentage of his income for food today as he did in 1940	19	22*
40(*a*)	It would take the average American worker more time today than it did in 1940 to earn the money needed to buy the same food he bought in 1940	38	39

(*a*) Indicates questions given special emphasis six months prior to 1959 survey.
* Indicates the difference in percentages tested significantly different by t test at the 5 percent level or better.

questions which tested significantly different in percent answering correctly for individual cities. The blank areas of the table indicate no significant difference for specific questions for individual cities.

It will be noted that a statistically significant difference was found in the analysis of the data from individual cities for six questions which did not show a significant difference for the total sample of the combined cities. This results because the change in a particular city showing a significant difference is not large enough to significantly influence the averages for the total sample. This happened when the changes in the other cities was very small or negative. There were no questions showing a significant difference for the total sample which did not also show a significant difference in at least one city.

TABLE 2—Comparison of responses to information questions showing a significant difference in response between 1957 and 1959 for each of four cities*

Question number	Subject	Kalamazoo		Muskegon		Flint		Grand Rapids		Total sample of four cities	
		1957	1959	1957	1959	1957	1959	1957	1959	1957	1959
		Percent of correct answers#									
13(*a*)	Small eggs	46	60(30)	...	.....	...	.....	43	50(16)	46	53(15)
15(*a*)	Grade B eggs	71	80(13)	...	.....	...	.....	...	.....	...	.....
17(*a*)	Pork loin	69	75(9)	...	.....	...	.....	...	.....	68	71(4)
18(*a*)	Pork cut costs	38	45(18)	...	.....	40	47(17)	...	.....	...	.....
19(*a*)	Relative lean in pork cuts	...	.....	22	29(32)	...	.....	...	.....	...	.....
20	Ham	58	66(14)	57	65(14)	55	62(13)	...	.....	58	64(10)
21(*a*)	Marbling	51	59(16)	43	52(21)	37	45(22)	42	50(19)	43	52(21)
25	Calories non fat dry skim milk	51	58(14)	49	56(14)	...	.....	...	.....	50	55(10)
29(*a*)	Grades of beef	69	76(10)	...	.....	...	.....	...	.....	...	.....
31(*a*)	Grades of beef	...	.....	...	.....	...	.....	53	59(11)	...	.....
33	Marbling and grades of beef	...	.....	...	.....	46	54(17)	...	.....	54	58(7)
34(*a*)	Apple varieties	...	.....	...	.....	77	84(9)	...	.....	80	83(4)
37	Apple grades	...	.....	...	.....	...	.....	10	15(50)	...	.....
38(*a*)	Food costs	20	29(45)	...	.....	...	.....	...	.....	19	22(16)

(*a*) Indicates questions that were given special emphasis starting six months prior to the second mailing.
* By t test at 5 percent level of significance.
# Numbers in ( ) indicate percentage increase in percent giving correct response.
..... A blank following a question indicates that no significant difference was found for that question in the particular city.

The data in Table 2 indicate a considerable variation in the change in response to particular questions among the four cities. In only one case was there a significant change in the number of correct responses to a question in each of the four cities (question 21 concerning marbling of beef). Seven questions had a significant change in response in two or three cities.

Subject matter seemed to have little relationship to change in response, as the questions with a significant change were spread throughout the major categories.

An attempt was made to obtain a measure of the frequency of mention of the subject matter related to the 12 questions receiving special attention by the information agents over the 2-year period. The frequencies are listed in Table 3. An explanation of the apparent high frequency for some of the questions, especially for Kalamazoo, is the fact that a large proportion of the times mentioned was on taped radio spot announcements and in a number of small circulation weekly newspapers. In no case was the subject treated extensively in more than two or three of the major newspaper releases. There was no way of evaluating the extent of treatment of the various subjects.

Even though the number of mentions is a very poor measure of relative emphasis in program, there is some indication of a relationship between data of Tables 2 and 3. The generally greater change in Kalamazoo corresponds to the greater frequency of mention of the questions.

Also the 12 questions singled out for special attention showed a stronger gain than those dealt with without special emphasis. Ten of the 12 special attention questions showed a significant change in at least one city compared with only four of the 12 other questions. The subjects of these "other" questions were included in information

TABLE 3—Approximate number of times subject of twelve selected questions was dealt with in mass media releases during 2-year period

Question number	Times mentioned		
	Kalamazoo	Grand Rapids	Flint
13	82	17	16
15	89	12	10
17	17	21	9
19	29	10	6
21	27	12	10
23	120	9	6
26	38	4	4
29	8	17	6
31	77	20	14
34	43	34	13
38	67	12	5
40	54	7	2

programs but were not emphasized or given special treatment. Thus, most of them would be included in releases in each media no more than two or three times during the 2-year period.

Change in Homemakers' Familiarity with Consumer Marketing Information Program

There was a significant increase in the number of people who said the information supplied by local Consumer Marketing Information Agents, such as Maryann Meldrum, Virginia Helt and Lysle Hutton, was helpful in their food buying. In 1957, 39 percent said they thought the food buying information was helpful, compared with 43 percent in 1959. There was also a significant increase of those who said they were familiar with the programs or articles of these agents. The increase was from 29 percent in 1957 to 32 percent in 1959. This represents a 10 percent increase in each case.

To offset any definite conclusion that may be made as to the awareness of homemakers of the Marketing Information for Consumers Program is the fact that a significantly increased number also said they were familiar with a fictitious person, "Alice Boyts."

Familiarity with Information Program Related to Changes in Response Rates

For each year, the sample was divided into those reporting they were familiar with the Consumer Marketing Information Program and those not. Table 4 shows a comparison of the percentage of correct responses for these groups for the nine questions, showing a statistically significant difference in response between years.

Those who said they were familiar with the program scored a larger percentage of correct answers in both years for every question. However, those familiar with the program showed only slightly more improvement than those not.

Differences in Socio-Economic Characteristics

The two samples were compared in terms of number of persons in the household, family income, amount spent for food, age of homemaker and education of homemaker. Using a chi-square test and a 5 percent level of significance, a statistically significant difference existed for the first three characteristics and no difference was found for the latter two. Although the differences were statistically significant,

TABLE 4—Comparison of responses to information questions showing a significant difference in response between 1957 and 1959 by homemakers reporting familiarity and no familiarity with consumer marketing information program

No.		Familiar with program		Not familiar with program	
		1957	1959	1957	1959
13	Small eggs are usually less expensive per pound than large eggs during September	55	62*	42	49*
16	The lower grades of beef do not have quite as much nutritional value as the higher grades	80	80	71	67*
17	The larger the percentage of the center section of a whole pork loin that is included in a pork roast, the more desirable it will be	73	79*	66	67
20	Most people would find that ham labeled "ready-to-eat" is cooked enough to eat without further cooking	61	68*	56	62*
21	The fat around the edge of beef is known as the marbling	53	65*	40	45*
25	(Nonfat dry skim milk) It has only about half the number of calories per glass as fluid whole milk	61	62	45	52*
29	The higher the grade of beef the less fat it will have.	75	73	65	69*
34	The Delicious variety of apple makes better pies than the MacIntosh variety	84	88*	78	81*
38	The average American worker is spending about the same percentage of his income for food today as he did in 1940	20	26*	18	20

* Indicates a significant difference of correct answers with the t test at the 5 percent level of significance.

they were relatively minor and not of a magnitude to suggest any significant influence on the study. Table 5 shows the comparative distribution of families by size. The changes in both income and amount spent for food were small and of a nature which could easily

*TABLE 5—Number of persons in household**

Number of people	Percent of households	
	1957	1959
1	6	7
2	27	29
3 or more	40	36
5 or more	25	26

* The frequency distributions tested significantly different at the 5 percent level by chi-square test.

have been the result of changes in economic conditions between the two periods.

Discussion

The data presented support the following conclusions:

(1) A measurable change in the level of knowledge about food buying took place between the bench mark and final survey;

(2) There was some relationship between the emphasis on a subject by the marketing program and the change in correct responses;

(3) There was some increase in awareness of the marketing program among homemakers;

(4) Homemakers reporting no familiarity with the program showed about as much increase in level of knowledge as those reporting a familiarity with it. However, those familiar with the program scored consistently higher on the quiz;

(5) The large sample, two-step opinion-quiz by mail survey provides a method for measuring relatively small changes in levels of knowledge.

Something needs to be said about the magnitude of the changes in level of knowledge. While many questions showed a statistically significant difference, the percentage of the total population influenced may appear small. It is important to look at these changes in perspective. It may be assumed for these cities that the homemakers in the standard metropolitan area react about the same as those of the central city—they are in contact with about the same newspapers, radio and television information releases. The standard metropolitan areas of the three cities studied which had agents included an average of over 90,000 homemakers.[4] Thus, a change involving only 1 percent of one of these cities involves about 900 homemakers. Therefore, even these relatively small percentage changes involve quite large numbers of people. The smallest difference which tested significantly different for the individual cities was about 3 percent. This would involve about 2,700 homemakers, which is about the total number of students a high school home economics teacher would contact through classroom teaching over a 25 to 30-year career. Similarly, it would take a great many conventional extension meetings to effectively get a point across to this many people. Accordingly, it is

[4] *Printer's Ink*, September 9, 1960, section two reports 109,000 households for Flint standard metropolitan area and 110,000 for Flint. A comparable figure for Kalamazoo would be about 53,000.

noted that the differences are not only statistically significant, but that they represent really significant numbers of people.

At the same time, it is obvious that there are large numbers of homemakers who were not effectively reached on these subjects. This suggests a need for careful study of means of effectively reaching them.

It should be recognized that the questions involved in the test represented only a very small part of the total subject matter of the agents' programs. Also, that many homemakers were reached who would give the correct answer to the quiz question, but who would nevertheless benefit from a discussion of the subject even if it only reinforced what they already knew. Effectively reaching this latter group does not show up in this test.

A question of a different sort is whether or not the changes in level of knowledge can be attributed to the information program. This question is especially relevant in view of the significant changes found in Muskegon, a city where the program was discontinued about 5 months after the initial survey, and the fact that significant changes were indicated for the group indicating no familiarity with the program.

It is not possible to rule out other sources as the basis of the changes in knowledge indicated. However, an attempt was made to select questions not likely to be treated by sources outside the program. Also, the better showing of questions given special emphasis (nine of the 12 showing a significant difference in at least one city) seems to lend support to conclusions that the changes were due to program activities.

As for Muskegon, the residents were within reach of many program releases from Grand Rapids, Kalamazoo, and Detroit dealing with the subjects of the quiz.

The significant differences found between the two groups reporting no familiarity with the program may indicate a lack of identification of material with the name of the program as well as the presence of alternative sources of information for these questions. Studies of audiences have also indicated a fairly large group of readers or listeners who do not identify the releases with the local Consumer Marketing Information Agent. The reader needs only ask himself the identity of newswriters or infrequently heard announcers to

realize that many people can read a news column or listen to a broadcast without remembering the identity of the organization or person providing the information.

The study does indicate the feasibility of evaluating changes in level of knowledge by means of mail survey. While it is difficult to get people to submit to an examination, it was found that 50 percent would return a quiz when it was presented as expressions of opinion.

The mail opinion-quiz survey provides information about relative levels of knowledge in different subject areas as well as measuring changes in level of knowledge. It could be devised to measure the differences in response through different media.

Suggestions for future studies using this technique to test ability of a program to change the level of knowledge include:

(1) Select a relatively short time period and put heavy emphasis on the subject of the quiz during the between survey periods—this reduces the chances of influence from other sources.

(2) Attempt to select questions which (a) represent subjects not likely to be covered by other sources, (b) are of great interest to homemakers, and (c) are such that few homemakers know the correct answers.

(3) Compute sample size so as to make it possible to test for small differences. It is unrealistic to expect large differences from mass media education.

The authors believe it is important to use two different samples in testing differences, since the influence of taking the first quiz will probably make the initial sample unrepresentative for a second survey. The respondents will be looking for the answers. It might be interesting to re-survey the initial sample, as well as an independent sample, to check the validity of this hypothesis.

MONTHLY CASH RECEIPTS, CASH OPERATING EXPENSES AND BALANCE ON MICHIGAN FARMS IN 1959[1]

By K. T. WRIGHT

Department of Agricultural Economics

In the Michigan Mail-in Accounting Project, the cooperating farmers send in to the Agricultural Economics Department of Michigan State University monthly reports of their farm receipts and expenses. Because it was felt that this monthly information would be of value to farmers, farm management specialists and planners, farm credit men, agriculture teachers and many others, these reports for 1959 were tabulated and averaged on a per farm basis for the various type of farming areas, and as an average for the 1103 farmer cooperators completing their accounts that year. This is the first time that such information on the monthly variations in cash farm receipts, cash operating expenses and cash balance has been made available.

Averages for All 1103 Farms

Before we discuss the financial aspects of these farms, a few words about the size and organization of the farms may be helpful. The acres and other physical aspects for all 1103 farms in this 1959 study, were not tabulated, but were for the 887 farms included in the various type-of-farming reports.[2] These 887 farms averaged 270 acres in size, with 200 of the acres tillable. Corn was the most important crop, occupying 27 percent of the tillable land. Alfalfa hay occupied 19 percent, tillable pasture 13 percent, oats 11 percent and wheat 10 percent. As to livestock, 88 percent had dairy cows, averaging 27 head per farm; 34 percent had hogs, averaging 10 sows, and 10 percent had sheep averaging 46 ewes per farm. Thirty-eight percent had poultry, averaging 357 hens per farm.

[1] Based upon results obtained from the mail-in accounting project conducted jointly by the Coop. Ext. Serv. and the Agr. Expt. Sta. and reported in a different manner in Agr. Econ. mimeographs 797 and 798 by Warren H. Vincent.

[2] Mich. Agr. Expt. Sta. Quart. Bul., Vol. 43, No. 1: 84-95.

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Monthly Cash Receipts

Total monthly cash receipts on the 1,103 farms averaged $1,656, or nearly $20,000 for the year of 1959 (Table 1). Receipts were the highest in July and December, $1,932 and $1,921, respectively (Fig. 1). They were the lowest in March and May, $1,376 and $1,389, respectively. Thus, for the entire group of farms, there was over $500 difference between the receipts in the low and high months. Table 1 shows that income from the sale of dairy products accounted for almost one-half the average monthly total and was relatively stable throughout the year, varying only from $648 to $804. July was the high month in total receipts due to cash crop sales, largely wheat. December was high because of sales of cash crops and feed grains, and somewhat larger than average receipts in several other items.

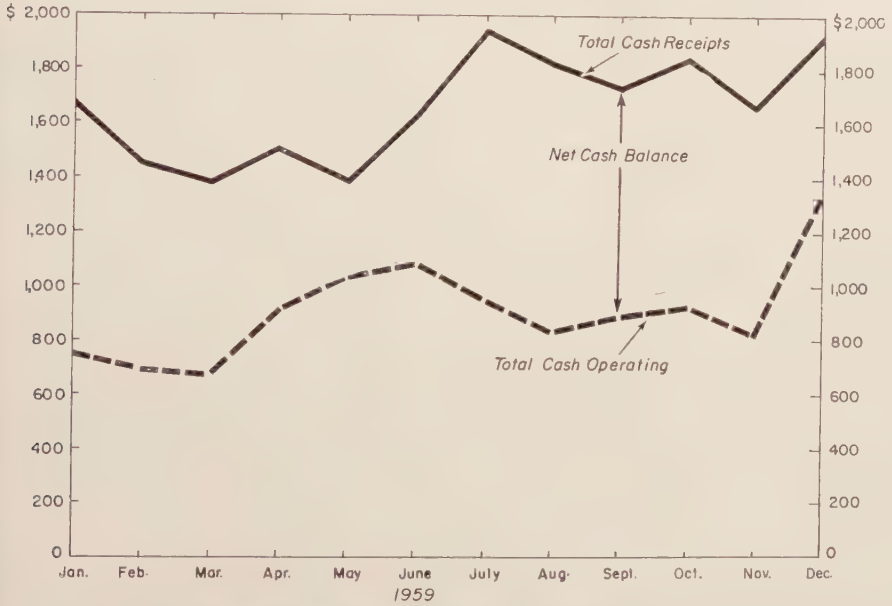

Fig. 1. Total monthly cash receipts, cash operating expenses and net cash balance, average for 1103 farms in the Mail-in Accounting Project, 1959.

Monthly Cash Farm Operating Expenses

Only cash farm operating expenses are included in this tabulation. Excluded are capital investments for new machinery, farm buildings, and livestock purchases. Debt payments, income tax payments and all family living expenses also are not included.

Total cash farm operating expenses on these 1,103 farms for 1959

TABLE 1—Details of monthly cash receipts, cash operating expenses and balance, state average, of 1103 farms in the mail-in accounting project, 1959

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Monthly average
CASH RECEIPTS													
Crops: Cash crops	$ 241	$ 119	$ 89	$ 126	$ 74	$ 64	$ 431	$ 182	$ 204	$ 180	$ 126	$ 287	$ 177
Feed grains	50	34	42	43	51	58	58	60	38	65	83	100	57
Fruit and truck	33	40	48	22	38	111	146	206	108	122	136	88	91
Other	9	11	17	14	10	7	11	7	8	13	2	9	10
Livestock: Dairy products	783	787	689	740	718	752	670	648	696	739	804	798	735
Dairy cattle	193	129	159	191	165	165	141	227	189	219	125	148	171
Beef cattle	51	79	59	122	134	247	203	256	191	236	111	88	148
Eggs	64	57	60	50	45	44	53	52	58	63	57	61	55
Poultry	9	3	15	6	5	15	6	9	19	7	13	46	13
Hogs	139	102	101	94	80	75	83	83	87	76	84	77	90
Sheep and wool	12	7	15	8	7	4	19	3	9	8	15	12	10
Other: Labor off-farm	26	28	34	27	25	27	24	21	24	29	24	54	29
Custom work	7	4	4	4	5	13	35	22	33	23	34	35	18
All other items	45	41	44	49	32	37	52	47	70	62	50	118	52
TOTAL	$1662	$1441	$1376	$1496	$1389	$1619	$1932	$1823	$1734	$1842	$1664	$1921	$1656
CASH OPERATING EXPENSES													
Labor hired	$ 80	$ 66	$ 62	$ 78	$ 96	$ 136	$ 180	$ 174	$ 132	$ 162	$ 99	$ 143	$ 117
Feed purchased	186	162	189	188	155	150	172	153	145	176	173	233	173
Crop expenses: Fertilizer	38	31	48	141	235	274	81	47	99	73	60	106	103
Seed and etc.	15	23	39	101	126	99	71	50	61	51	42	42	60
Machinery: Fuel and oil	39	38	44	80	99	100	102	82	87	80	70	70	74
Repairs and supplies	35	35	45	67	74	82	82	67	68	66	54	62	61
Truck and auto	31	45	32	29	24	23	31	29	27	31	33	52	32
Hired and custom	5	3	3	5	6	15	29	22	28	33	29	32	17
Improvements: Repairs	13	9	12	22	25	19	23	26	28	34	28	36	23
Insurance	8	14	13	7	10	12	10	13	25	20	19	16	14
Livestock expenses: Marketing	60	60	56	61	60	64	59	58	57	60	61	58	60
Breeding, veterinary medicine, etc.	41	38	36	37	35	31	33	35	34	41	43	59	38
Taxes on farm	120	84	10	2	...	2	...	...	1	...	2	195	35
Interest paid	26	27	28	37	36	30	25	26	36	39	42	97	37
Rent paid	14	15	9	10	10	11	13	13	19	18	23	75	19
Electricity, telephone and miscellaneous	41	43	40	40	36	33	40	36	35	40	40	52	40
TOTAL	$ 752	$ 693	$ 666	$ 905	$1027	$1081	$ 951	$ 831	$ 882	$ 924	$ 818	$1328	$ 903
NET CASH BALANCE	$ 910	$ 748	$ 710	$ 591	$ 362	$ 538	$ 981	$ 992	$ 852	$ 918	$ 846	$ 593	$ 753

averaged $903 a month, or almost $11,000 for the year. As mentioned above, this does not include the capital investment purchases of new machinery, farm improvements or livestock (these will be in the 1960 tabulation), which on the 887 farms, averaged over $6,000 a year, or $500 a month. Thus, if these were the same on the 1,103 farms, the cash operating expense, plus capital investments would average about $1,400 a month, or approximately $250 a month less than cash receipts.

Like the cash receipts, the cash farm operating expenses in 1959 varied widely from month to month, ranging from "lows" of $666 in March and $693 in February, to "highs" of $1,081 in June and $1,328 in December, or a variation from low to high of $662 (Fig. 1). Table 1 shows that June expenses were high largely because of fertilizer payments, plus slightly larger than average expenses for a few other items. December expenses, however, were the highest, due to payment of taxes on the farm, larger than average feed purchases and a few other items.

Net Cash Balance

Net Cash Balance is the term applied to the difference between the cash receipts and the cash farm operating expenses. Thus, the net cash balance is the amount left each month from the cash receipts, for (a) the capital purchases or investment items, (b) family living expenses, (c) debt payments, (d) income taxes, and (e) any other uses.

The average net cash balance on these farms ranged from a low of $362 in May to a high of $992 in August, with a monthly average for 1959 of $753 (Table 1). As pointed out previously, the capital purchases on 887 of the 1,103 farms averaged about $500 a month, thus the cash balance for family living, etc., as mentioned above, probably was in the order of $250.

Comparative Monthly Variation in Total Receipts, Expenses and Balance

Expressed on a dollar basis, the range from the low month to the high month in average cash receipts for this group of farms in 1959 was $556, while the range in cash operating expenses was $662, and in cash balance $630.

The monthly variation in total cash receipts, operation expenses and net balance can be measured by expressing each as a percentage of its monthly average for the year (see Fig. 2 and Tables 2—7). Fig-

ure 2 shows graphically the monthly variation for the total cash receipts, the operating expenses, and the cash balance, on this basis. This graph indicates that the total cash receipts had the smallest monthly fluctuations over the year, the total operating expenses the next, and the cash balance the most.

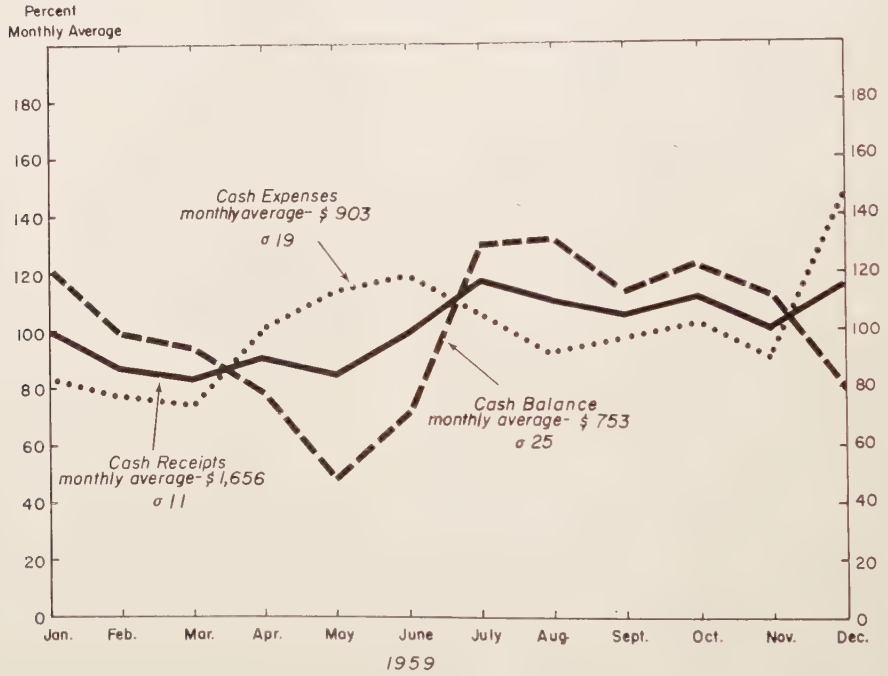

Fig. 2. Monthly indexes of total cash receipts, cash operating expenses and balance for 1103 farms in the Mail-in Accounting Project, 1959 (Monthly average in each case = 100).

This variation can be measured more accurately by calculating the standard deviation of the 12 months from the index of the monthly average for the year. (Tables 5—7). The standard deviation of the average monthly cash receipts for the entire group of farms was 11.6, which means that a range of that much on each side of 100 (88.4 to 111.6) would include 68 percent of the months (assuming a normal distribution). The standard deviation for the average monthly cash operating expenses was 19.2, or some 65 percent more than the receipts variation. The standard deviation of the average monthly cash balance was 25.3, or slightly over double the monthly variation in the cash receipts.

TABLE 2—Total monthly cash receipts: Average of farms in the mail-in accounting project, by type-of-farming areas, 1959

Area	No. farms	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Monthly average
1	73	$2341	$1815	$1695	$1685	$1891	$2940	$2627	$2551	$2019	$2600	$1772	$2140	$2153
2	122	1616	1446	1552	1621	1233	1374	2235	2112	1802	1928	1584	1825	1696
3 and 11	46	1185	1458	1547	1244	1362	2888	3718	4548	2415	2710	2754	2431	2356
4	64	1801	1590	1461	1419	1591	1298	1814	1643	1647	1637	1677	1759	1612
5	282	1913	1703	1573	1800	1451	1840	2430	1696	1981	1943	1831	2001	1848
6 and 7	131	1871	1633	1423	1545	1493	1689	1719	2065	1857	1924	2014	2091	1780
8	95	1778	1198	1171	1515	1510	1402	1617	1774	2049	1742	1593	3274	1720
10	78	1616	1504	1342	1468	1473	1322	1451	1536	1683	1751	1528	1537	1517
9, 12 and 14	115	1045	932	1025	1132	1169	992	953	1034	970	1557	1052	1257	1093
15, 16 and 17	97	945	951	876	962	915	1076	1047	935	956	1137	980	1062	993
Average of all	1103	$1662	$1441	$1376	$1496	$1389	$1619	$1932	$1823	$1734	$1842	$1664	$1921	$1656

TABLE 3—Total monthly cash operating expenses:(a) Average of farms in the mail-in accounting project, by type-of farming areas, 1959

Area	No. farms	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Monthly average
1.....	73	$ 869	$ 970	$ 821	$1003	$1106	$1443	$1223	$ 936	$1044	$1188	$1011	$1689	$1112
2.....	122	702	650	672	1052	1166	992	884	823	920	921	769	1534	927
3 and 11.....	46	737	825	770	1122	1478	1803	2754	2484	1688	2082	1577	1692	1589
4.....	64	854	696	737	946	1036	971	899	856	816	985	793	1443	918
5.....	282	857	787	710	999	1123	1143	1033	814	988	963	985	1450	987
6 and 7.....	131	864	786	806	964	1136	1224	989	905	942	992	829	1457	992
8.....	95	688	550	517	885	925	1336	697	678	809	838	790	1697	866
10.....	78	796	711	694	826	1053	1039	770	829	969	864	713	1171	870
9, 12 and 14.....	115	585	522	519	655	721	717	557	521	508	534	399	702	582
15, 16 and 17.....	97	485	486	488	586	691	586	670	493	490	560	499	581	557
Average of all...	1103	$ 752	$ 693	$ 666	$ 905	$1027	$1081	$ 951	$ 831	$ 882	$ 924	$ 818	$1328	$ 903

(a) Does not include cash outlay for purchases of livestock, new machinery or farm improvements, debt payments, income taxes, or family living.

TABLE 4—Monthly cash balance:(a) Average of farms in the mail-in accounting project, by type-of-farming areas, 1959

Area	No. farms	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Monthly average
1	73	$1472	$ 845	$ 874	$ 682	$ 785	$1497	$1404	$1615	$ 975	$1412	$ 761	$ 451	$1041
2	122	914	796	880	569	67	382	1351	1289	882	1007	815	291	769
3 and 11	46	448	633	776	123	−116	1084	964	2064	726	628	1178	740	767
4	64	947	894	724	473	555	327	915	787	831	652	884	316	694
5	282	1056	916	863	801	328	697	1397	882	993	980	846	551	861
6 and 7	131	1007	847	618	581	357	465	730	1160	915	932	1185	634	788
8	95	1090	648	654	630	585	66	920	1096	1240	904	803	1577	854
10	78	820	793	648	642	420	283	681	707	714	887	815	366	647
9, 12 and 14	115	460	410	506	478	448	275	396	513	462	1023	653	555	511
15, 16 and 17	97	460	465	388	376	224	490	377	442	466	577	481	481	436
Average of all...	1103	$ 910	$ 748	$ 710	$ 591	$ 362	$ 538	$ 981	$ 992	$ 852	$ 918	$ 846	$ 593	$ 753

(a) Balance is amount left for purchases of livestock, new equipment or farm improvements, debt payments, income taxes, family living, and savings.

TABLE 5—Monthly indexes of total cash receipts for farms in mail-in accounting project, by type-of-farming areas, 1959

(monthly average in each area = 100)

Area	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Monthly average	Standard deviation
1	109	84	79	78	88	137	122	118	94	121	82	99	100	19.1
2	95	85	92	96	73	81	132	125	106	114	93	108	100	16.9
3 and 11	50	62	66	53	58	123	158	193	103	115	117	103	100	43.0
4	112	99	91	88	99	81	113	102	102	102	104	109	100	9.2
5	104	92	85	97	79	100	131	92	107	105	99	108	100	12.6
6 and 7	105	92	80	87	84	95	97	116	104	108	113	117	100	12.0
8	103	70	68	88	88	82	94	103	119	101	93	190	100	30.4
10	107	99	88	97	97	87	96	101	111	115	101	101	100	7.9
9, 12 and 14	96	85	94	104	107	91	87	95	89	142	96	115	100	15.1
15, 16 and 17	95	96	88	97	92	108	105	94	96	114	99	107	100	8.3
Average of all	100	87	83	90	84	98	117	110	105	111	100	116	100	11.6

TABLE 6—Monthly indexes of total cash operating expenses for farms in mail-in accounting project, by type-of-farming areas, 1959

(monthly average in each area = 100)

Area	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Monthly average	Standard deviation
1	78	87	74	90	99	130	110	84	94	107	91	152	100	21.5
2	76	70	72	113	126	107	95	89	99	99	83	165	100	25.5
3 and 11	46	52	48	71	93	113	173	156	106	131	99	106	100	39.2
4	93	76	80	103	113	106	98	93	89	107	86	157	100	20.2
5	87	80	72	101	114	116	105	82	100	98	100	147	100	19.1
6 and 7	87	79	81	97	115	123	100	91	95	100	84	147	100	18.9
8	79	64	60	102	107	154	80	78	93	97	97	91	100	23.3
10	91	82	80	95	121	119	89	95	111	99	82	135	100	17.0
9, 12 and 14	101	90	89	113	124	123	96	90	87	92	69	121	100	16.4
15, 16 and 17	87	87	88	105	124	105	120	89	88	101	90	104	100	12.5
Average of all	83	77	74	100	113	119	105	92	97	102	90	147	100	19.2

TABLE 7—Monthly indexes of cash balance for farms in mail-in accounting project, by type-of-farming areas, 1959

(monthly average in each area = 100)

Area	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Monthly average	Standard deviation
1	141	81	84	66	75	144	135	155	94	136	73	43	100	36.0
2	119	104	114	74	9	50	176	168	115	131	106	38	100	47.9
3 and 11	58	83	101	16	−15	141	126	269	95	82	154	95	100	64.8
4	136	129	104	68	80	47	132	113	120	94	127	46	100	31.2
5	123	106	100	93	38	81	162	102	115	114	98	64	100	29.4
6 and 7	128	107	78	74	45	59	93	147	116	118	150	80	100	32.2
8	128	76	77	74	69	8	108	128	145	106	94	185	100	43.0
10	127	123	100	99	65	44	105	109	110	137	126	57	100	28.5
9, 12 and 14	90	80	99	94	88	54	77	100	90	200	128	109	100	34.5
15, 16 and 17	106	107	89	86	51	112	86	101	107	132	110	110	100	19.2
Average of all	121	99	94	78	48	71	130	132	113	122	112	79	100	25.3

Type-of-Farming Area Comparisons

All that has been said thus far applied to the entire group of farms in the Mail-in Accounting Project. There are many different types of farming in this state (Fig. 3), and quite likely the monthly variations in receipts, expenses and balance, differ widely. The Farm Management Extension Specialists of the Agricultural Economics Department grouped the farms in the Mail-in Accounting Project in 1959 into 10 areas or combinations of type-of-farming areas. It was decided to make the same grouping in this analysis of monthly variations in receipts, expenses and balance. Thus, we can compare the average monthly figures for the farmers in the project in the various type-of-farming areas. It should be pointed out, however, that not all farms in an area are organized as the typical farm, and the figures we present should not be thought of as strictly for a particular type of farm, but rather for the farms in an area with a particular type designation.

The average monthly *total* cash receipts, cash farm operating expenses and balance for each of the 10 areas or combinations of areas are shown on Tables 2-7. (The *detailed* figures for the various items of income and expenses for these 10 areas are shown in Tables 8-17, for those who wish to study the causes of the variations in the monthly totals, or wish to know about the variation in particular income or expense items.)

While it is outside the limits of this article to compare and analyze the monthly variations in each of the 10 areas, a brief comparison of four different areas is illustrative and points out at least some of the variations associated with type-of-farming. The four selected areas are: Area 1—"General Livestock and Corn," Areas 3 and 11—"Fruit, Vegetables and Dairy," Area 5—"Dairy and General Farming" and Area 8—"Cash Crops and Dairy."

Monthly Cash Receipts

For the purpose of comparing the monthly variations in cash receipts in the four selected areas, it was thought best to do it on the basis of the index numbers or percentages of the monthly average. (The average total dollars of receipts monthly for each area, from which these were calculated, are shown in Table 2, and the indexes in Table 5.)

The graphic comparison of the monthly indexes of cash receipts of the four selected areas (Fig. 4) shows not only a great difference in the monthly pattern of the high and low months, but also far

more monthly variation in receipts in some areas than others. For instance, Area 1 monthly receipts were at their peak in June, due to sales of beef cattle. Areas 3 and 11 receipts were highest in August, because of high fruit and vegetable sales. July was the high month in Area 5, due to wheat sales; while December was the high month in Area 8, because of sales of cash crops and beef cattle.

With respect to the amount of monthly variation in the cash receipts among the four areas, Area 5, with its relatively high and

Fig. 3. Shown are Michigan's 83 counties grouped into type-of-farming areas. The "natural" boundaries of these areas do not, however, follow county boundaries, but rather are lines representing the influences of soil, climate and markets.

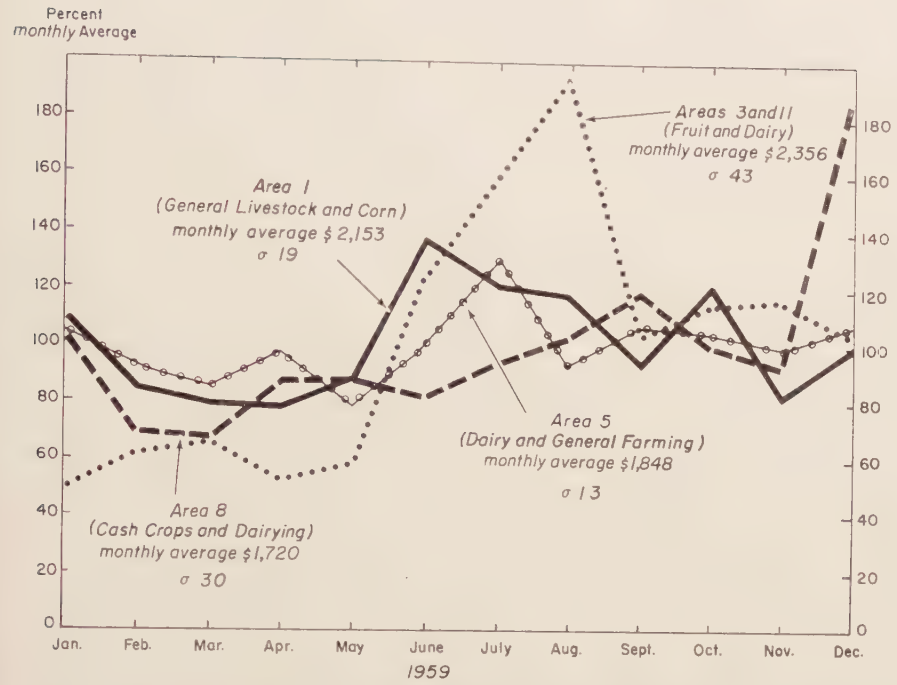

Fig. 4. Comparison of monthly indexes of cash receipts in four different type-of-farming areas, 1959 (monthly average in each area = 100).

stable dairy income, showed the least variation, with a range in average monthly receipts of $1,451 to $2,430, and a standard deviation of 12.6. Area 1 was next with a monthly range from $1,685 to $2,940, and a standard deviation of 19.1. Area 8 monthly receipts ranged from $1,171 to $3,274, with a standard deviation of 30.4. Areas 3 and 11 showed the widest fluctuation, with a range in monthly receipts of $1,244 to $3,718, and a standard deviation of 43.0. In other words, the monthly fluctuations in cash receipts on the farms in Areas 3 and 11 ("Fruit, Vegetables and Dairy") were over three times as great, percentagewise, as in Area 5 ("Dairy and General Farming.")

Monthly Cash Operating Expenses

There was also a considerable difference in the monthly pattern of the high and low months among the four selected areas in cash operating expenses, as well as in the amount of the monthly variation. In 1959 in Area 1, expenses were highest in December,[3] largely because of payment of farm taxes, cash rent, and fertilizer purchases

[3] This might not have been true if the purchases of feeder cattle had been included.

(Fig. 5). July was the peak month in Areas 3 and 11, due to the high labor expense; while December was the highest month in Area 5, because of taxes on the farm, interest paid and several other items. June was the peak month in Area 8, mainly because of payments for fertilizer. March was the month of lowest expense in all four areas.

In regard to the amount of monthly variation in cash operating expenses among the four areas, Area 5 again showed the least variation, with a range in average monthly expenses of $710 to $1,450, and a standard deviation of 19.1 (Tables 3 and 6). Area 1 was next with a range of $831 to $1,689, and a standard deviation of 21.5. Area 8 monthly expense average ranged from $517 to $1,336, with a standard deviation of 23.3. Areas 3 and 11 again showed the greatest variation, having a range of $770 to $2,754, with a standard deviation of 39.2, or more than twice that of Area 5.

Monthly Cash Balance

With there being wide monthly variations in cash receipts and cash operating expenses, even wider variations would be expected in the remaining balance. (Fig. 6).

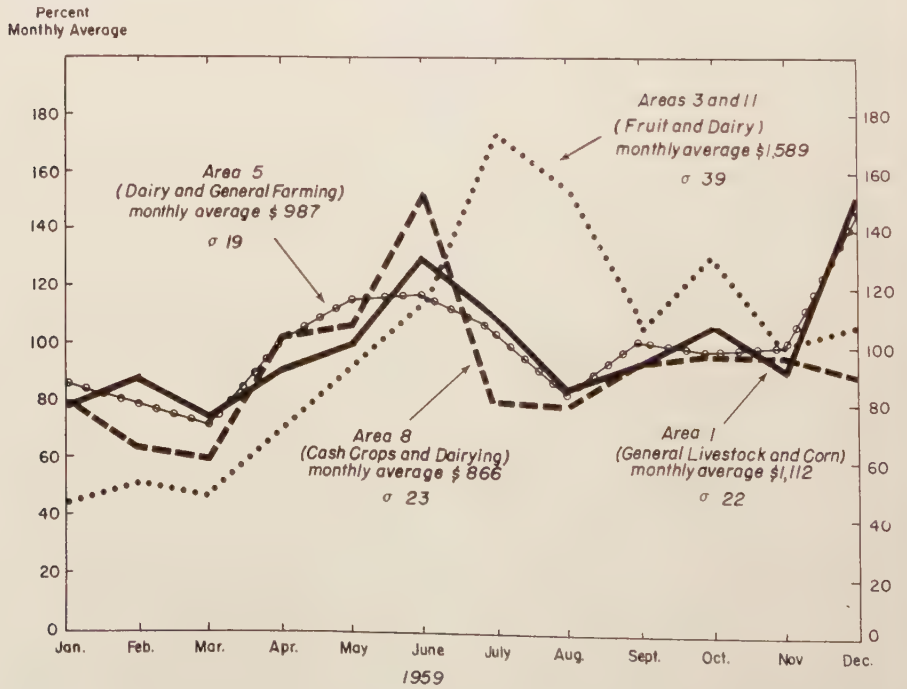

Fig. 5. Comparison of monthly indexes of cash operating expenses in four different type-of-farming areas, 1959 (monthly average in each area = 100).

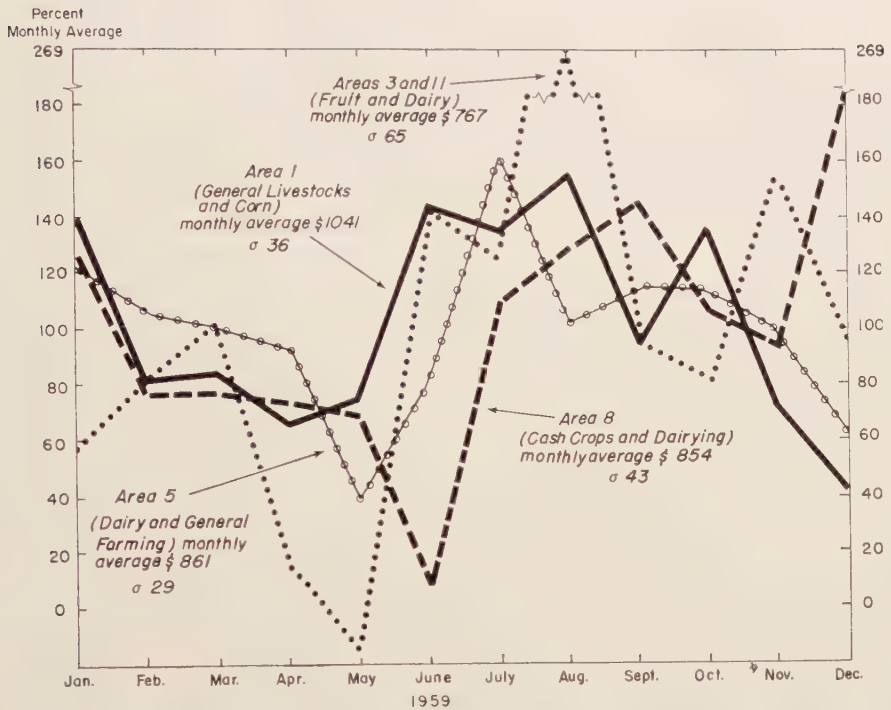

Fig. 6. Comparison of monthly indexes of cash balance in four different type-of-farming areas, 1959 (monthly average in each area = 100).

In 1959, the monthly cash balance in Area 5 ranged from $328 in May, or 38 percent of the monthly average for the year, to $1,397 in July, or 132 percent of monthly average, with a standard deviation of 29.4 (Tables 4 and 7). Area 1 was next with a range from $682 in April, or 66 percent of the average for the year, to $1,615 in August, or 155 percent of the monthly average, with a standard deviation of 36.0. Area 8 showed a range in cash balance from $66 in June, only 8 percent of the monthly average, to $1,577 in December, which was 185 percent of the average, with a standard deviation of 43.0. Areas 3 and 11 had a deficit cash balance of $116 in May, but an average balance of $2,064 in August, and a standard deviation of 64.8. Thus, the "Fruit, Vegetable and Dairy Area" farms in the group had over twice the monthly variation in monthly balance as those in Area 5.

It is obvious that these maximum variations of $1,000 to over $2,000 in the monthly cash balance, as an average for a group of farms in an area, indicate a great fluctuation in farmers' cash position

and the amount and duration of their credit needs. It is hoped that the information presented here will help farmers, farm planners, and farm credit persons in appreciating the great monthly variations in receipts, expenses and balance, and the timing of those variations, which so greatly affect farmers' current financial position.

TABLE 8—Area 1—Monthly cash receipts, cash operating expenses and balance 1959; average of 73 farms in mail-in accounting project

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Monthly average
CASH RECEIPTS													
Crops: Cash crops	$ 284	$ 132	$ 94	$ 27	$ 9	$ 75	$ 404	$ 40	$ 182	$ 217	$ 66	$ 157	$ 141
Feed grains	244	59	106	112	146	115	116	106	44	140	194	381	147
Fruit and truck	...	...	...	...	...	...	...	14	52	284	...	23	31
Other	8	4	3	7	13	6	4	9	23	8	1	17	9
Livestock: Dairy products	782	739	677	743	709	717	645	621	662	722	783	817	718
Dairy cattle	281	146	236	178	150	134	116	494	122	192	131	117	191
Beef cattle	123	263	178	237	610	1,587	904	804	490	569	172	134	506
Eggs	80	65	75	63	51	52	63	69	89	85	65	72	69
Poultry	2	1	2	1	7	4	4	3	17	12	1	2	5
Hogs	454	321	203	217	135	174	261	186	164	200	237	137	224
Sheep and wool	39	28	39	23	15	7	24	7	19	17	42	21	23
Other: Labor off-farm	26	23	31	51	27	24	26	27	43	46	24	75	35
Custom work	6	1	5	6	6	7	23	13	40	31	19	114	23
All other items	12	33	46	20	13	38	37	158	72	77	37	73	31
TOTAL	$2341	$1815	$1695	$1685	$1891	$2940	$2627	$2551	$2019	$2600	$1772	$2140	$2153
CASH OPERATING EXPENSES													
Labor hired	$ 93	$ 85	$ 80	$ 96	$ 115	$ 108	$ 116	$ 136	$ 147	$ 111	$ 97	$ 152	$ 111
Feed purchased	267	228	237	257	205	277	376	260	243	273	276	278	265
Crop expenses: Fertilizer	68	5	66	98	189	476	174	30	78	119	99	252	138
Seed and etc.	22	14	44	92	119	108	63	55	51	116	35	62	63
Machinery: Fuel and oil	63	46	58	94	127	121	114	78	100	97	67	72	86
Repairs and supplies	45	38	78	100	94	94	94	74	88	91	47	47	74
Truck and auto	41	44	37	39	27	28	26	41	36	37	40	62	44
Hired and custom	7	7	1	7	2	11	43	15	39	49	50	79	26
Improvements: Repairs	21	9	24	35	34	21	19	37	33	22	36	34	27
Insurance	8	23	12	5	2	11	3	2	19	37	33	46	17
Livestock expenses: Marketing	65	59	56	58	77	70	64	72	64	78	66	63	66
Breeding, veterinary medicine, etc.	48	47	37	40	45	33	39	37	31	58	52	61	44
Taxes on farm	54	228	16	...	...	...	...	...	...	...	5	226	44
Interest paid	15	42	30	35	30	43	40	24	59	42	40	72	39
Rent paid	11	52	8	10	4	7	20	25	17	23	36	126	28
Electricity, telephone and miscellaneous	41	43	37	37	36	35	32	50	39	35	32	57	40
TOTAL	$ 869	$ 970	$ 821	$1003	$1106	$1443	$1223	$ 936	$1044	$1188	$1011	$1689	$1112
BALANCE	$1472	$ 845	$ 874	$ 682	$ 785	$1497	$1404	$1615	$ 975	$1412	$ 761	$ 451	$1041

TABLE 9—Area 2—Monthly cash receipts, cash operating expenses, and balance 1959; average of 122 farms in mail-in accounting project

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Monthly average
CASH RECEIPTS													
Crops: Cash crops	$ 150	$ 62	$ 25	$ 20	$ 5	$ 32	$ 668	$ 145	$ 119	$ 122	$ 20	$ 49	$ 118
Feed grains	46	86	107	104	55	87	79	105	98	110	113	120	93
Fruit and truck	3	...	...	...	2	16	10	72	44	17	...	2	14
Other	7	11	12	9	8	5	6	9	4	9	2	7	8
Livestock: Dairy products	619	629	588	616	597	638	571	567	568	611	671	672	612
Dairy cattle	145	134	157	165	91	143	151	468	142	155	121	121	166
Beef cattle	26	44	86	210	95	91	312	268	272	425	213	73	176
Eggs	95	85	94	81	83	74	91	91	98	100	93	101	91
Poultry	4	2	5	3	2	3	5	12	3	13	2	211	22
Hogs	411	272	325	306	248	218	237	282	333	261	241	218	279
Sheep and wool	11	25	39	32	5	6	26	7	26	2	46	17	20
Other: Labor off-farm	32	27	50	35	30	29	27	26	26	36	29	37	32
Custom work	2	1	...	1	1	16	19	11	22	9	14	26	10
All other items	65	68	64	39	11	16	33	49	47	58	19	171	55
TOTAL	$1616	$1446	$1552	$1621	$1233	$1374	$2235	$2112	$1802	$1928	$1584	$1825	$1696
CASH OPERATING EXPENSES													
Labor hired	$ 55	$ 51	$ 44	$ 84	$ 80	$ 118	$ 100	$ 109	$ 88	$ 88	$ 52	$ 133	$ 84
Feed purchased	244	196	237	255	206	215	225	204	192	229	281	427	243
Crop expenses: Fertilizer	23	28	55	214	358	198	93	64	147	99	43	116	120
Seed and etc.	6	9	27	94	128	78	30	38	50	37	13	10	43
Machinery: Fuel and oil	32	31	41	79	90	85	83	56	84	64	52	64	63
Repairs and supplies	32	34	43	58	75	82	81	59	59	62	37	56	56
Truck and auto	29	39	33	25	24	21	36	33	28	25	28	42	31
Hired and custom	5	3	1	9	9	19	44	35	31	51	23	33	22
Improvements: Repairs	11	12	18	45	18	23	19	37	40	41	38	34	28
Insurance	7	4	5	4	13	10	17	26	34	20	8	18	14
Livestock expenses: Marketing	48	50	48	56	50	54	50	56	51	53	55	49	52
Breeding, veterinary medicine, etc.	44	49	38	44	46	42	44	47	43	50	52	79	48
Taxes on farm	96	75	10	...	...	...	...	...	2	2	4	222	35
Interest paid	28	27	32	49	29	15	17	21	39	53	32	136	40
Rent paid	5	2	5	3	6	5	9	10	3	15	14	63	12
Electricity, telephone and miscellaneous	37	40	35	40	34	27	36	28	29	32	37	52	36
TOTAL	$ 702	$ 650	$ 672	$1059	$1166	$ 992	$ 884	$ 823	$ 920	$ 921	$ 769	$1534	$ 927
BALANCE	$ 914	$ 796	$ 880	$ 562	$ 67	$ 382	$1351	$1289	$ 882	$1007	$ 815	$ 291	$ 769

TABLE 10—Areas 3 and 11—Monthly cash receipts, cash operating expenses, and balance 1959; average of 46 farms in mail-in accounting project

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Monthly average
CASH RECEIPTS													
Crops: Cash crops	$ 10	$ 2	$ 2	$ 48	$ 36	$ ...	$ 58	$ 24	$ 34	$ 88	$ 13	$ 18	$ 28
Feed grains	...	2	22	...	6	8	25	23	4	4	...	2	8
Fruit and truck	742	925	1124	553	841	2456	3215	3988	1936	2249	2282	1780	1840
Other	1	1	8	37	76	1	8	2	2	2	4	4	12
Livestock: Dairy products	165	180	170	194	186	192	176	154	154	157	162	148	170
Dairy cattle	48	40	93	170	25	38	16	33	26	7	38	29	47
Beef cattle	42	22	11	36	...	...	...	178	110	...	74	26	42
Eggs	44	42	42	30	26	22	28	20	18	32	20	29	29
Hogs	13	8	12	8	24	10	14	8	14	5	2	2	10
Sheep and wool	...	...	...	...	...	...	...	...	...	...	...	...	..
Other: Labor off-farm	38	88	40	48	66	80	46	43	32	49	68	74	56
Custom work	2	4	1	2	2	2	84	16	2	24	32	30	17
All other items	80	144	20	117	74	77	48	55	81	92	57	285	95
TOTAL	$1185	$1458	$1547	$1244	$1362	$2887	$3718	$4548	$2415	$2709	$2754	$2431	$2356
CASH OPERATING EXPENSES													
Labor hired	$ 185	$ 144	$ 191	$ 289	$ 357	$ 890	$1576	$1518	$ 940	$1242	$ 558	$ 358	$ 688
Feed purchased	51	46	78	85	46	54	52	41	36	50	34	70	54
Crop expenses: Fertilizer	40	41	68	137	143	86	76	99	72	26	24	156	81
Seed and etc.	69	292	153	282	509	356	512	376	225	340	510	308	329
Machinery: Fuel and oil	40	50	40	72	160	125	118	88	82	109	88	66	86
Repairs and supplies	29	32	47	90	94	89	102	70	80	60	68	86	71
Truck and auto	42	49	50	44	29	29	45	50	45	59	31	109	48
Hired and custom	2	1	1	6	2	10	8	13	24	51	15	6	12
Improvements: Repairs	8	8	12	20	26	19	40	31	22	16	26	24	21
Insurance	14	5	12	3	11	9	12	28	34	7	6	28	14
Livestock expenses: Marketing	11	14	14	18	13	16	14	17	11	10	17	8	14
Breeding, veterinary medicine, etc.	14	15	14	11	12	7	9	8	12	17	18	22	15
Taxes on farm	128	24	12	1	...	...	12	4	6	...	...	258	37
Interest paid	36	32	16	22	36	48	61	59	24	22	28	59	37
Rent paid	16	2	5	...	...	14	...	2	24	4	64	59	16
Electricity, telephone and miscellaneous	52	70	57	41	40	51	117	79	51	69	90	74	66
TOTAL	$ 737	$ 825	$ 770	$1121	$1478	$1803	$2754	$2483	$1688	$2082	$1577	$1691	$1589
BALANCE	$ 448	$ 633	$ 777	$ 123	$ −116	$1084	$ 964	$2065	$ 727	$ 627	$1177	$ 740	$ 767

TABLE 11—Area 4—Monthly cash receipts, cash operating expenses, and balance 1959; average of 64 farms in mail-in accounting project

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Monthly average
CASH RECEIPTS													
Crops: Cash crops	$ 333	$ 223	$ 136	$ 99	$ 5	$ 1	$ 293	$ 42	$ 226	$ 110	$ 155	$ 168	$ 149
Feed grains	49	9	3	20	11	10	52	57	26	32	5	53	27
Fruit and truck	...	...	...	...	...	3	58	62	61	...	...	...	16
Other	4	26	16	7	7	11	9	1	1	3	2	3	8
Livestock: Dairy products	801	806	729	802	816	834	744	713	747	769	834	898	791
Dairy cattle	230	193	172	153	347	140	189	246	202	256	126	146	200
Beef cattle	5	3	3	14	149	27	169	174	36	147	182	16	77
Eggs	238	195	197	169	140	143	167	161	161	179	172	167	174
Poultry	13	10	17	80	7	9	16	81	24	19	32	95	34
Hogs	75	69	125	39	55	54	53	64	57	49	85	75	67
Sheep and wool	2	...	10	...	8	...	13	...	...	2	2	...	3
Other: Labor off-farm	24	20	35	17	29	28	16	18	22	27	19	21	23
Custom work	3	16	1	1	2	2	4	4	27	4	16	31	9
All other items	24	20	17	18	15	36	31	20	57	40	47	86	34
TOTAL	$1801	$1590	$1461	$1419	$1591	$1298	$1814	$1643	$1647	$1637	$1677	$1759	$1612
CASH OPERATING EXPENSES													
Labor hired	$ 103	$ 43	$ 50	$ 51	$ 79	$ 93	$ 112	$ 91	$ 56	$ 154	$ 50	$ 151	$ 86
Feed purchased	295	250	308	344	265	236	270	297	195	290	241	314	275
Crop expenses: Fertilizer	14	32	37	127	196	143	51	51	106	60	55	50	77
Seed and etc.	5	40	37	82	117	70	30	27	70	29	45	61	52
Machinery: Fuel and oil	24	40	31	75	87	99	82	78	75	74	41	75	65
Repairs and supplies	33	33	39	45	55	70	88	60	50	54	42	35	50
Truck and auto	25	39	23	22	22	20	26	24	19	23	26	39	26
Hired and custom	9	10	3	6	6	20	35	18	21	33	27	15	17
Improvements: Repairs	19	12	19	18	33	23	22	28	26	29	26	48	25
Insurance	2	13	12	3	5	15	7	12	34	50	13	11	15
Livestock expenses: Marketing	66	64	60	68	65	74	69	66	62	67	66	66	66
Breeding, veterinary medicine, etc.	43	41	35	42	28	27	30	28	33	45	44	40	36
Taxes on farm	143	9	10	...	...	...	...	...	...	...	...	235	33
Interest paid	22	17	26	20	25	24	24	30	29	25	43	135	35
Rent paid	15	8	11	4	22	21	13	11	9	18	26	108	22
Electricity, telephone and miscellaneous	36	45	36	39	31	36	40	35	31	34	48	60	39
TOTAL	$ 854	$ 696	$ 737	$ 946	$1036	$ 971	$ 899	$ 856	$ 816	$ 985	$ 793	$1443	$ 918
BALANCE	$ 947	$ 894	$ 724	$ 473	$ 555	$ 327	$ 915	$ 787	$ 831	$ 652	$ 884	$ 316	$ 694

TABLE 12—Area 5—Monthly cash receipts, cash operating expenses, and balance 1959; average of 282 farms in mail-in accounting project

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Monthly average
CASH RECEIPTS													
Crops: Cash crops	$ 171	$ 117	$ 34	$ 129	$ 13	$ 20	$ 742	$ 139	$ 180	$ 121	$ 83	$ 146	$ 158
Feed grains	82	57	69	45	80	100	114	52	57	72	172	178	90
Fruit and truck	1	...	...	...	2	...	4	9	16	13	20	7	6
Other	16	24	17	17	10	11	28	10	12	35	3	7	16
Livestock: Dairy products	1019	1016	859	933	870	924	792	738	834	909	1036	1027	913
Dairy cattle	208	147	190	231	117	211	178	189	257	255	150	158	191
Beef cattle	58	134	83	187	143	354	239	345	279	281	85	71	188
Eggs	55	51	53	45	37	38	45	40	45	48	43	48	46
Poultry	26	...	47	1	10	46	13	5	56	5	32	58	25
Hogs	162	101	100	100	85	73	84	81	92	81	102	97	97
Sheep and wool	18	8	25	8	17	5	36	7	13	16	15	12	15
Other: Labor off-farm	26	21	27	17	18	19	23	19	17	21	16	56	23
Custom work	10	1	3	6	9	14	70	29	56	38	28	34	25
All other items	61	26	66	81	40	25	62	33	67	48	46	102	55
TOTAL	$1913	$1703	$1573	$1800	$1451	$1840	$2430	$1696	$1981	$1943	$1831	$2001	$1848
CASH OPERATING EXPENSES													
Labor hired	$ 96	$ 75	$ 68	$ 80	$ 100	$ 127	$ 150	$ 128	$ 105	$ 108	$ 97	$ 167	$ 108
Feed purchased	183	181	182	193	162	158	177	163	180	208	199	232	185
Crop expenses: Fertilizer	49	26	44	158	281	287	99	53	129	95	103	117	120
Seed and etc.	11	9	33	109	117	90	57	33	68	34	18	28	51
Machinery: Fuel and oil	42	47	47	91	100	105	125	84	88	94	86	79	82
Repairs and supplies	44	37	49	76	88	103	97	80	73	77	73	73	72
Truck and auto	35	44	32	28	25	24	37	28	22	31	35	53	33
Hired and custom	5	3	7	5	6	17	49	18	35	32	40	33	21
Improvements: Repairs	14	13	10	20	26	18	26	24	24	40	36	39	24
Insurance	9	10	11	8	14	12	10	12	34	21	34	18	16
Livestock expenses: Marketing	79	79	69	76	70	77	70	68	68	69	79	70	73
Breeding, veterinary medicine, etc.	52	46	48	45	38	36	41	42	43	49	56	77	49
Taxes on farm	152	125	18	1	...	3	...	...	...	...	2	220	43
Interest paid	32	30	38	53	49	43	39	36	57	47	69	123	51
Rent paid	9	16	10	13	8	7	14	9	24	16	17	65	17
Electricity, telephone and miscellaneous	45	46	44	43	39	36	42	36	38	42	41	56	42
TOTAL	$ 857	$ 787	$ 710	$ 999	$1123	$1143	$1033	$ 814	$ 988	$ 963	$ 985	$1450	$ 987
BALANCE	$1056	$ 916	$ 863	$ 801	$ 328	$ 697	$1397	$ 882	$ 993	$ 980	$ 846	$ 551	$ 861

TABLE 13—Areas 6 and 7—Monthly cash receipts, cash operating expenses, and balance 1959; average of 131 farms in mail-in accounting project

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Monthly average
CASH RECEIPTS													
Crops: Cash crops	$ 217	$ 58	$ 32	$ 107	$ 41	$ 41	$ 254	$ 416	$ 162	$ 198	$ 161	$ 181	$ 155
Feed grains	17	13	12	26	35	82	28	160	26	74	80	41	50
Fruit and truck	...	...	...	...	...	3	...	19	18	13	1	1	5
Other	9	6	25	25	6	8	6	8	5	...	3	6	9
Livestock: Dairy products	1106	1135	959	1032	998	1034	939	911	1013	1079	1181	1126	1043
Dairy cattle	239	116	172	134	198	174	180	150	266	306	206	367	209
Beef cattle	82	105	70	80	70	177	128	245	144	34	184	60	115
Eggs	66	56	61	53	50	42	44	47	60	68	62	76	57
Poultry	8	5	1	3	3	7	5	3	5	4	9	7	5
Hogs	57	72	40	41	29	44	50	26	20	26	38	43	40
Sheep and wool	...	...	1	1	2	2	2	1	...	3	2	2	2
Other: Labor off-farm	10	33	19	15	11	25	18	13	19	19	14	92	25
Custom work	2	6	4	3	3	28	24	30	18	19	16	11	14
All other items	58	28	27	25	47	22	41	36	101	80	57	78	51
TOTAL	$1871	$1633	$1423	$1545	$1493	$1689	$1719	$2065	$1857	$1923	$2014	$2091	$1780
CASH OPERATING EXPENSES													
Labor hired	$ 91	$ 74	$ 80	$ 88	$ 108	$ 116	$ 134	$ 140	$ 124	$ 142	$ 116	$ 128	$ 112
Feed purchased	193	171	206	166	155	140	146	152	130	175	162	196	166
Crop expenses: Fertilizer	44	19	98	119	275	370	146	55	104	78	46	60	118
Seed and etc.	18	3	46	115	124	98	60	47	64	34	20	18	54
Machinery: Fuel and oil	38	40	42	78	104	115	109	116	100	84	80	74	82
Repairs and supplies	44	43	50	90	94	88	89	93	94	104	69	74	78
Truck and auto	30	39	29	26	26	24	25	26	30	31	37	57	32
Hired and custom	6	2	2	4	5	10	16	34	22	30	18	36	16
Improvements: Repairs	20	12	20	32	20	15	36	28	30	48	23	73	30
Insurance	8	22	12	10	5	24	12	12	20	16	15	18	14
Livestock expenses: Marketing	70	70	68	74	72	76	72	62	70	69	74	76	71
Breeding, veterinary medicine, etc.	52	54	53	50	51	44	51	51	46	58	54	89	54
Taxes on farm	146	140	14	17	...	2	1	...	4	...	...	216	45
Interest paid	32	27	16	28	28	40	23	29	36	46	38	166	42
Rent paid	24	23	24	22	22	24	27	24	26	29	32	120	33
Electricity, telephone and miscellaneous	48	47	45	45	46	38	42	36	42	48	45	56	45
TOTAL	$ 864	$ 786	$ 805	$ 964	$1136	$1224	$ 989	$ 905	$ 942	$ 992	$ 829	$1457	$ 992
BALANCE	$1007	$ 847	$ 618	$ 581	$ 357	$ 465	$ 730	$1160	$ 915	$ 931	$1185	$ 634	$ 788

TABLE 14—Area 8—Monthly cash receipts, cash operating expenses, and balance 1959; average of 95 farms in mail-in accounting project

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Monthly average
CASH RECEIPTS													
Crops: Cash crops	$ 820	$ 289	$ 301	$ 430	$ 489	$ 308	$ 759	$ 642	$ 920	$ 586	$ 364	$1725	$ 636
Feed grains	23	33	34	76	83	56	47	71	19	173	66	89	64
Fruit and truck	2	...	...	...	...	...	15	68	84	...	1	14	15
Other	7	2	14	10	11	4	2	2	7	...	2	18	7
Livestock: Dairy products	547	571	486	512	493	513	414	444	479	488	536	530	501
Dairy cattle	181	88	116	158	144	196	59	63	156	182	101	61	125
Beef cattle	16	64	40	178	167	123	103	325	223	147	198	464	171
Eggs	29	29	26	20	19	16	20	29	33	30	31	26	26
Poultry	...	2	...	...	1	4	...	1	3	5	1	...	1
Hogs	52	57	80	90	73	68	48	43	37	37	19	45	54
Sheep and wool	3	5	6	2	3	...	7	...	4	8	7	9	5
Other: Labor off-farm	41	14	27	17	14	24	17	13	14	36	25	55	25
Custom work	4	...	2	8	1	15	30	9	19	25	199	78	33
All other items	53	44	39	14	13	75	96	64	51	25	43	159	57
TOTAL	$1778	$1198	$1171	$1515	$1511	$1402	$1617	$1774	$2049	$1742	$1593	$3273	$1720
CASH OPERATING EXPENSES													
Labor hired	$ 49	$ 38	$ 35	$ 51	$ 64	$ 79	$ 135	$ 146	$ 75	$ 78	$ 85	$ 159	$ 83
Feed purchased	116	100	114	131	107	78	121	83	97	107	85	245	115
Crop expenses: Fertilizer	73	78	15	195	219	664	34	47	103	133	110	199	156
Seed and etc.	14	5	28	116	115	114	48	64	49	48	36	72	59
Machinery: Fuel and oil	42	22	54	92	108	104	88	72	112	92	94	72	79
Repairs and supplies	26	34	45	81	66	72	60	58	83	72	62	88	62
Truck and auto	39	48	40	41	31	31	43	47	46	52	44	73	44
Hired and custom	5	...	5	5	4	24	16	26	33	26	63	71	23
Improvements: Repairs	6	5	5	20	25	13	22	15	31	16	19	29	17
Insurance	9	32	36	10	11	9	6	5	19	22	19	12	16
Livestock expenses: Marketing	40	39	36	42	40	39	33	34	33	32	35	37	36
Breeding, veterinary medicine, etc.	29	22	23	29	29	22	22	20	28	26	30	40	27
Taxes on farm	109	42	...	...	...	9	...	2	...	...	7	299	39
Interest paid	32	23	34	24	54	28	15	10	24	51	19	60	31
Rent paid	60	27	11	12	21	24	23	16	49	43	46	188	43
Electricity, telephone and miscellaneous	39	35	36	36	31	26	31	33	27	40	36	53	36
TOTAL	$ 688	$ 550	$ 517	$ 885	$ 925	$1336	$ 697	$ 678	$ 809	$ 838	$ 790	$1697	$ 866
BALANCE	$1090	$ 648	$ 654	$ 630	$ 586	$ 66	$ 920	$1096	$1240	$ 904	$ 803	$1576	$ 854

TABLE 15—Areas 9, 12 and 14—Monthly cash receipts, cash operating expenses, and balance 1959; average of 115 farms in mail-in accounting project

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Monthly average
CASH RECEIPTS													
Crops: Cash crops	$ 38	$ 77	$ 119	$ 107	$ 89	$ 25	$ 43	$ 65	$ 26	$ 44	$ 89	$ 145	$ 80
Feed grains	...	1	...	5	6	4	2	9	2	...	1	3	3
Fruit and truck	...	1	...	...	...	3	13	6	...	...	...	66	8
Other	1	2	6	6	1	6	4	12	...	7	...	2	4
Livestock: Dairy products	612	602	574	580	571	632	574	565	597	620	627	604	596
Dairy cattle	209	123	166	276	339	151	136	198	144	299	124	126	183
Beef cattle	60	13	19	42	31	18	26	13	9	351	10	29	52
Eggs	38	23	37	19	21	28	38	43	49	58	54	49	37
Poultry	1	4	10	1	1	9	2	2	2	1	8	1	4
Hogs	22	15	8	9	20	12	12	25	22	5	16	18	15
Sheep and wool	9	1	6	3	2	6	21	3	10	10	21	23	10
Other: Labor off-farm	25	30	41	42	33	28	23	25	24	21	22	49	30
Custom work	9	9	8	9	6	8	21	23	32	13	3	26	14
All other items	21	31	31	33	49	62	38	45	53	128	77	116	57
TOTAL	$1045	$ 932	$1025	$1132	$1169	$ 992	$ 953	$1034	$ 970	$1557	$1052	$1257	$1093
CASH OPERATING EXPENSES													
Labor hired	$ 43	$ 58	$ 26	$ 37	$ 44	$ 60	$ 67	$ 51	$ 44	$ 60	$ 39	$ 66	$ 50
Feed purchased	187	134	198	153	121	115	119	100	88	115	94	151	131
Crop expenses: Fertilizer	11	16	21	89	152	112	11	36	43	15	9	34	46
Seed and etc.	4	4	20	62	80	64	45	25	25	7	5	13	29
Machinery: Fuel and oil	37	28	38	68	79	87	81	71	68	59	50	62	61
Repairs and supplies	24	28	29	44	44	59	50	37	41	29	25	27	37
Truck and auto	27	46	25	27	17	19	20	18	17	23	26	35	26
Hired and custom	4	2	2	1	9	21	8	20	15	23	7	20	11
Improvements: Repairs	8	5	5	8	14	17	14	19	23	31	13	13	14
Insurance	6	13	15	6	6	8	16	12	9	11	11	10	11
Livestock expenses: Marketing	63	61	64	64	62	75	66	62	65	68	27	59	64
Breeding, veterinary medicine, etc.	28	29	23	26	25	24	20	22	25	25	25	34	25
Taxes on farm	91	37	2	1	...	...	...	...	...	...	1	94	19
Interest paid	16	18	13	28	32	16	8	12	12	30	26	41	21
Rent paid	3	11	2	8	3	10	2	6	4	4	12	10	6
Electricity, telephone and miscellaneous	33	32	36	33	33	30	30	30	29	34	29	32	31
TOTAL	$ 585	$ 522	$ 519	$ 655	$ 721	$ 717	$ 557	$ 521	$ 508	$ 534	$ 399	$ 701	$ 582
BALANCE	$ 460	$ 410	$ 506	$ 477	$ 448	$ 275	$ 396	$ 513	$ 462	$1023	$ 653	$ 556	$ 511

TABLE 16—Area 10—Monthly cash receipts, cash operating expenses, and balance 1959; average of 78 farms in mail-in accounting project

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Monthly average
CASH RECEIPTS													
Crops: Cash crops	$ 284	$ 196	$ 175	$ 138	$ 80	$ 52	$ 296	$ 113	$ 215	$ 424	$ 275	$ 262	$ 209
Feed grains	...	...	2	11	7	7	4	18	34	14	4	5	9
Fruit and truck	...	1	3	...	30	122	12	131	27	23	2	3	30
Other	9	8	24	17	12	10	5	6	15	4	3	5	10
Livestock: Dairy products	804	812	704	753	795	762	678	674	744	768	775	784	754
Dairy cattle	242	211	216	222	212	114	121	342	252	196	97	96	193
Beef cattle	105	52	34	69	152	76	119	61	140	110	5	28	79
Eggs	48	47	46	41	37	34	47	39	40	42	35	43	42
Poultry	1	2	...	3	12	2	2	2	3	7	2	15	4
Hogs	27	64	83	66	85	58	47	72	49	47	39	64	58
Sheep and wool	26	...	...	6	...	10	18	...	4	...	...	28	8
Other: Labor off-farm	30	35	34	35	31	23	35	24	38	40	36	50	34
Custom work	4	...	2	8	1	15	30	9	19	25	199	78	33
All other items	36	76	19	99	19	37	37	45	103	51	56	76	54
TOTAL	$1616	$1504	$1342	$1468	$1473	$1322	$1451	$1536	$1683	$1751	$1528	$1537	$1517
CASH OPERATING EXPENSES													
Labor hired	$ 93	$ 86	$ 74	$ 81	$ 112	$ 162	$ 111	$ 167	$ 176	$ 221	$ 96	$ 153	$ 128
Feed purchased	183	152	189	171	150	127	145	141	113	120	128	218	153
Crop expenses: Fertilizer	35	61	25	112	234	237	66	33	121	32	25	104	91
Seed and etc.	37	20	63	94	116	101	47	46	95	73	31	25	62
Machinery: Fuel and oil	30	39	42	82	103	106	94	107	90	67	67	76	75
Repairs and supplies	40	41	50	53	88	88	91	87	71	50	67	58	65
Truck and auto	32	77	34	21	31	24	30	27	22	24	31	68	36
Hired and custom	3	6	3	5	6	8	18	14	34	18	28	6	12
Improvements: Repairs	9	6	12	17	43	20	16	29	25	42	34	37	24
Insurance	7	7	15	7	8	9	9	14	38	23	16	8	13
Livestock expenses: Marketing	58	60	57	64	60	63	52	58	58	62	56	57	59
Breeding, veterinary medicine, etc.	36	37	32	31	27	24	26	33	31	36	41	49	33
Taxes on farm	164	30	1	...	...	...	...	1	3	...	...	143	29
Interest paid	21	29	49	40	29	26	14	24	33	40	39	80	35
Rent paid	5	17	8	8	10	9	14	17	25	19	16	29	15
Electricity, telephone and miscellaneous	43	43	40	40	36	35	37	31	34	37	38	60	40
TOTAL	$ 796	$ 711	$ 694	$ 826	$1053	$1039	$ 770	$ 829	$ 969	$ 864	$ 713	$1171	$ 870
BALANCE	$ 820	$ 793	$ 648	$ 642	$ 420	$ 283	$ 681	$ 707	$ 714	$ 887	$ 815	$ 366	$ 647

TABLE 17—Areas 15, 16 and 17—Monthly cash receipts, cash operating expenses, and balance 1959; average of 97 farms in mail-in accounting project

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Monthly average
CASH RECEIPTS													
Crops: Cash crops	$ 100	$ 60	$ 73	$ 72	$ 59	$ 132	$ 44	$ 21	$ 16	$ 20	$ 66	$ 129	$ 68
Feed grains	2	3	2	4	9	23	14	1	3	...	...	...	5
Fruit and truck	...	...	...	...	...	1	4	9	4	2	17	...	3
Other	13	6	23	5	5	1	6	3	2	21	1	17	9
Livestock: Dairy products	628	658	591	637	653	694	702	678	631	642	660	635	651
Dairy cattle	113	117	65	140	111	134	130	116	118	158	58	92	113
Beef cattle	...	1	...	...	4	...	...	4	13	147	4	...	14
Eggs	37	35	35	29	27	32	37	37	40	44	47	49	37
Poultry	...	13	1	1	4	...	1	2	5	4	2	1	3
Hogs	1	...	...	...	3	8	...	...	1	1	2	1	2
Sheep and wool	1	...	...	...	...	2	6	...	6	...	10	...	2
Other: Labor off-farm	16	24	33	26	20	22	24	15	33	24	29	42	26
Custom work	6	4	12	7	5	9	11	29	19	21	14	14	13
All other items	28	30	41	41	15	18	68	20	65	53	70	83	47
TOTAL	$ 945	$ 951	$ 876	$ 962	$ 915	$1076	$1047	$ 935	$ 956	$1137	$ 980	$1063	$ 993
CASH OPERATING EXPENSES													
Labor hired	$ 47	$ 55	$ 45	$ 41	$ 55	$ 57	$ 87	$ 64	$ 56	$ 108	$ 47	$ 77	$ 61
Feed purchased	122	121	149	139	120	87	127	95	95	123	140	125	121
Crop expenses: Fertilizer	11	25	42	100	140	67	21	12	10	2	2	6	37
Seed and etc.	8	10	15	33	75	65	83	21	17	15	16	12	32
Machinery: Fuel and oil	31	30	35	57	79	67	93	65	71	62	53	45	57
Repairs and supplies	20	23	26	32	31	53	63	42	36	41	33	45	38
Truck and auto	16	38	24	23	16	15	18	16	33	27	26	25	25
Hired and custom	2	2	1	1	3	4	16	26	19	21	3	6	9
Improvements: Repairs	9	7	8	10	25	27	19	21	25	27	18	28	18
Insurance	12	15	5	6	10	7	8	5	7	10	4	6	8
Livestock expenses: Marketing	50	51	46	51	55	58	66	52	50	55	49	46	52
Breeding, veterinary medicine, etc.	29	25	32	23	27	29	22	25	23	24	26	38	28
Taxes on farm	80	20	3	1	...	...	...	...	2	...	3	49	13
Interest paid	13	29	10	33	15	13	12	5	8	7	36	22	17
Rent paid	4	3	12	4	10	3	3	8	11	5	14	13	8
Electricity, telephone and miscellaneous	31	32	35	32	30	34	32	36	27	33	29	38	33
TOTAL	$ 485	$ 486	$ 488	$ 586	$ 691	$ 586	$ 670	$ 493	$ 490	$ 560	$ 499	$ 581	$ 557
BALANCE	$ 460	$ 465	$ 388	$ 376	$ 224	$ 490	$ 377	$ 442	$ 466	$ 577	$ 481	$ 482	$ 436

SOIL MOISTURE STUDIES WITH CONTAINER-GROWN PLANTS

By JACK S. WIKLE, HAROLD DAVIDSON *and* EARL A. ERICKSON

Departments of Horticulture and Soil Science

Growing nursery stock in containers is an established practice in some sections of the United States and is increasing in importance in many other areas. Container production of plants affords several advantages; namely, more uniform conditions for plant growth, extension of the marketing and planting season, and the merchandising of plants in attractive prepackaged consumer units.

Container production of plants however, does, present certain problems to the grower. Reisch (2) has recently reviewed some of these problems and reported on the work now in progress directed toward improving cultural practices. He and Baker (2, 1) have indicated that there is little available information directly concerned with moisture relationships and problems in the irrigation of container-grown nursery stock.

Work done in the early 1900's established certain basic soil moisture concepts. A number of very excellent reviews are available covering this past work (3, 4, and 5).

The purpose of this study was to secure information of value in establishing irrigation practices for container-grown nursery stock by determining the effects of various moisture stresses ranging from slightly less than waterholding capacity to the permanent wilting percentage on the growth of *Phaseolus vulgaris, L.* 'Kentucky Wonder', and *Forsythia intermedia,* Zabel plants grown in containers.

PROCEDURE

The *Phaseolus vulgaris* and *Forsythia intermedia* plants were grown under five moisture regimes in 1-gal. metal containers in a greenhouse at Michigan State University, East Lansing. The growing media used were sand, a sand-peat mixture, and a sand-peat-clay loam mix-

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ture. Media mixtures contained equal parts by volume of each component. The percentages of water retained by samples of the media while subjected to various moisture stresses were determined by use of pressure plate and pressure membrane apparatus as described by Richards (3). The stresses developed under the five moisture regimes and the percentages of water retained at these stresses are given in Table 1.

TABLE 1—The moisture stress developed at time of irrigation under five moisture regimes and the percent moisture retained on an oven dry basis

Medium	Moisture stress developed				
	Midway between waterholding capacity and 0.1 atm. stress	0.1 atm. stress	1 atm. stress	5 atm. stress	15 atm. stress
Sand	9.77	2.76	1.44	1.00	0.67
Sand-peat	39.59	25.75	19.58	13.25	8.21
Sand-peat-clay loam	33.54	29.97	19.20	12.50	6.74

In Experiment 1, 60 containers, 20 of each media, were planted with seeds of *Phaseolus vulgaris* on June 17, 1959. The weights of the containers together with seeds, media, and percentages of water determined for the various moisture stresses were calculated. All the containers were weighed daily and irrigated when weight loss indicated that the selected moisture stress had been reached.

A split-plot design was used in which the major split was for media and the minor split was for moisture regime. Moisture regimes were randomized within media and media were randomized in each of four replicates.

The plants were harvested on July 15, 1959, and oven dry weights of roots and shoots were taken. The data was subjected to analysis of variance and results are tabulated in Table 2.

In Experiment 2, plants of *Forsythia intermedia* were planted on July 23, 1959. This experiment was similar to Experiment 1; however, the growing media were limited to 20 containers of sand-peat mixture and 20 containers of sand-peat-clay loam mixture. Weighings were made twice daily to maintain maximum control over the moisture regimes.

TABLE 2—Influence of five moisture regimes on the growth of Phaseolus vulgaris grown in three media

Moisture regime	Mean shoot growth (Grams of oven dry weight)	Mean root growth (Grams of oven dry weight)
1. (Irr. below 0.1 atm. stress)	1.93	1.55
2. (Irr. at 0.1 atm. stress)	1.90	1.86
3. (Irr. at 1 atm. stress)	1.70	1.56
4. (Irr. at 5 atm. stress)	1.18	1.09
5. (Irr. at 15 atm. stress)	0.73	0.96
L.S.D. .05	0.31	0.48
L.S.D. .01	0.41	0.65

The forsythia plants were harvested on September 30, 1959. Again, oven dry weights of roots and shoots were taken and data was subjected to analysis of variance with the results tabulated in Table 3.

RESULTS

Tables 2 and 3 show that irrigation at a stress midway between waterholding capacity and 0.1 atm. produced a maximum of shoot growth for bean plants, but it significantly reduced the shoot growth of forsythia plants. This indicates that forsythia plants may be more sensitive to high moisture levels than bean plants.

Irrigation at 0.1 atm. of tension resulted in a maximum of growth for both forsythia and bean plants.

TABLE 3—Influence of five moisture regimes on growth of Forsythia intermedia grown in two media

Moisture regime	Mean shoot growth (Grams of oven dry weight)	Mean root growth (Grams of oven dry weight)
1. (Irr. below 0.1 atm. stress)	3.69	5.06
2. (Irr. at 0.1 atm. stress)	5.28	6.65
3. (Irr. at 1 atm. stress)	5.26	5.81
4. (Irr. at 5 atm. stress)	3.99	4.81
5. (Irr. at 15 atm. stress)	2.19	3.26
L.S.D. .05	1.37	0.31
L.S.D. .01	1.86	0.42

Irrigation at 1 atm. of stress produced good growth of bean plants and forsythia shoots; however, it significantly reduced the growth of forsythia roots.

Irrigation at 5 atm. of stress was a more critical regime. It significantly reduced the growth of both beans and forsythia.

Irrigation at 15 atm. of stress resulted in a minimum of growth of both bean and forsythia plants.

Growth response to differences in media was also subjected to analysis of variance. Differences in plant growth between sand-peat and in sand-peat-clay loam mixtures were not significant. There was a significant difference in bean plant growth between those grown in sand and those grown in the sand-peat or the sand-peat-clay loam mixtures.

CONCLUSIONS

The results of moisture regime experiments on growth of bean and forsythia plants produced in 1-gal. metal containers indicates that the soil moisture should be maintained at relatively high levels, but at a level below waterholding capacity. It is indicated that maximum growth can be produced when the soil is irrigated after 0.1 atm., but before 1.0 atm. of moisture stress has developed. The soil should not be allowed to dry to a point where 5 or more atmospheres of moisture stress has developed since growth of the plants was significantly reduced.

The results of these studies also indicate that the sand-peat and sand-peat-clay loam media were equal in their water supplying ability as indicated by plant growth.

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ECONOMICS OF DRY-LOT DAIRYING IN MICHIGAN AND CALIFORNIA[1]

By C. R. HOGLUND

Department of Agricultural Economics

Dairy farming in California is characterized by specialization and large scale operations. Dairymen in Southern California have for many years purchased most of their feed and herd replacements. This is an area of high land values and high wage rates. In the metropolitan Los Angeles area, performance and wage rates for milkers are established through a farm labor union.

Michigan dairy farmers who have made substantial increases in the size of their dairy herds have tended to buy more of the concentrates but have continued to grow most of their forage requirements. A few dairymen have purchased substantial quantities of hay. It is anticipated that many Michigan dairy farmers will buy large quantities of both grain and hay as they expand the number of cows milked. The question is, "Will it be profitable for Southern Michigan dairymen to purchase most or all of their feed and herd replacements?"

To provide economic information about this possibility, several alternative feed and herd replacement plans were developed.

The first step was to determine the feed inputs, labor requirements, equipment and housing needs, investments, receipts, and expenses for five sizes of dry-lot dairy farms in Southern California. These operations were most nearly like those found in the Chino-Ontario area, a relatively new and fast developing dry-lot dairy section of western San Bernadino and Riverside Counties. Information for this phase of the study was obtained during November and December of 1960 when the author interviewed dairy farmers,

[1] The author is especially grateful to the following persons who provided technical and financial information relating to dry-lot dairy farming: Carlos Cartlidge, Don Addis, and James Oliver farm advisors, respectively, of Los Angeles, Riverside, and San Bernadino Counties, C. L. Pellisier, Extension Dairyman, Arthur Schultis, Extension Economist, and C. O. McCorkle, Jr. of the Department of Agricultural Economics, University of California. Appreciation is also given to Mark O. Temme of the Bureau of Milk Stabilization, California Department of Agriculture, Howard Stover of the California Crop and Livestock Reporting Service, and to other technical and professional personnel who supplied price, input-output, credit and other information needed in making an economic analysis of dairy farming.

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county farm advisors, University of California research and extension personnel, and milk market and credit agency personnel in California.

A second phase of the study included a budgetary analysis of alternative plans for growing and buying feed and herd replacements for 4 herd sizes in Southern Michigan. Level, productive soils and the use of improved feed production practices were assumed. The assumed yields per acre were 3.8 tons of conditioned, baled hay, 95 bushels of corn for grain, and 16 tons of corn silage. These are the net quantities available for feeding after deducting harvesting and storage losses.

The results of this two-phase study are reported in this article. More general observations on dairy farming in California have been published.[2]

THE BUDGETARY ANALYSIS

The budgeting technique was used in calculating receipts, expenses, and net income for the various alternatives studied. Input-output data obtained from dairy farmers, and technical and economic specialists, and from published reports on research findings, provided the basis for a budgetary analysis of alternative feed and herd replacement plans for Southern California and Southern Michigan.

Major Alternatives Studied

Alternatives studied included buying all feed and replacements, growing the feed and buying the replacements, and growing both feed and replacements. The alternative A of buying all feed and replacements described as dry-lot dairying was the only one budgeted for California (Table 1). The Michigan budgets included all three alternatives.

Southern California

A budgetary analysis was made of 5 herd sizes for Southern California. These included the following number of cows: 75, 110, 170, 225, and 335 cows (Table 1). Dairy extension specialists and others concerned with advising dairymen on financing or other phases of dairy farming in Southern California generally suggested that dairy herds of less than 100 cows were uneconomical when a full-time hired man was employed. Two alternative plans were developed

[2] Hoglund, C. R. (1961), California dairy farming, observations and economic appraisal. Michigan Agricultural Experiment Station Agricultural Economics paper 838.

TABLE 1—Estimated acres of land and months of labor for alternative feed and replacement plans, Southern California and Southern Michigan

	Alternative plans					
	1	2	3	4	5	6
Southern California						
Number of cows	75	75	110	170	225	335
A. Buy feed and replacements						
Acres of land	10	10	12	15	18	24
Months of labor						
Operator and family	18.0	18.0	18.0	18.0	18.0	18.0
Hired						
Milkers	....	12.0(*a*)	12.0	24.0(*a*)	24.0	36.0
Other dairy	2.0	....	2.5	5.0	17.0	24.0
Total months	20.0	30.0	32.5	47.0	59.0	78.0
Southern Michigan						
Number of cows	65	65	110	170	225	....
B. Buy feed and replacements						
Acres of land	12	12	15	19	24	....
Months of labor						
Operator and family	18.0	18.0	18.0	18.0	18.0	....
Hired						
Milkers	....	12.0	12.0	24.0	24.0	....
Other dairy	2.5	....	2.5	12.0	24.0	....
Total months	20.5	30.0	32.5	54.0	66.0	....
C. Grow feed and buy replacements						
Acres of land	165	165	275	332	480	....
Months of labor						
Operator and family	18.0	18.0	18.0	18.0	18.0	....
Hired						
Milkers	....	12.0	12.0	24.0	24.0	....
Other dairy	2.5	....	6.0	12.0	24.0	....
Field work	5.5	2.0	9.0	11.0	16.0	....
Total months	26.0	32.0	45.0	65.0	82.0	....
D. Grow feed and replacements						
Acres of land	230	230	350	465	635	....
Months of labor						
Operator and family	18.0	18.0	18.0	18.0	18.0	....
Hired						
Milkers	....	12.0	12.0	24.0	24.0	....
Other dairy	4.0	....	10.0	17.0	24.0	....
Field work	7.0	5.0	11.0	15.0	24.0	....
Total months	29.0	35.0	51.0	74.0	90.0	....

(*a*) Also assist with other dairy chores.

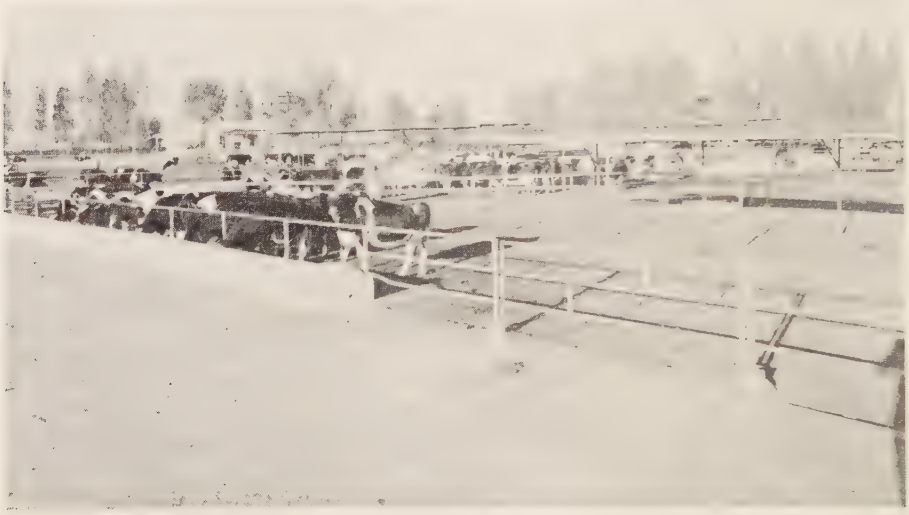

Fig. 1. Dry-lot dairying includes only enough land for buildings, lots, corrals, and hay and other feed storage. Total investments for a 225 cow operation are nearly the same for Michigan and California.

for the 75 cow operation. A1 used only the labor of the operator and his family, and about two months of hired labor; and the A2 alternative employed a full-time hired man to milk the 75 cows, with the operator and his son doing the other dairy chores. Milking labor was hired for the other four herd sizes.

All feed and replacements were purchased. Minimum requirements of land for buildings, lots, corrals, hay, and other feed storage, and lanes were provided. These acres ranged from 10 to 24 for the five sizes of herds.

Southern Michigan

The budgetary analysis of alternative feed and replacement plans included four herd sizes which were the same as the first four in California except Plans 1 and 2 for which cows were reduced to 65, mainly because of the greater expected labor requirements in caring for dairy cows in Michigan during the winter period. Three combinations of feed and replacement alternatives were budgeted for these four sizes of herds, namely:

B buying all feed and replacements,

C growing feed but buying all replacements,

D growing most of the feed and all of the replacements.

The acres of land required for the dry-lot dairy alternatives were estimated to be about 25 percent greater than for the respective herd sizes in the California budgets. Because of higher annual rainfall, snow, and freezing weather it was estimated that more lot space would be required per cow in Michigan than in California. The acres of land needed for alternatives C and D are shown in Table 1.

ASSUMPTIONS FOR THE BUDGETS

Inputs and Performance Rates For California

Labor and equipment

The operator and a 17-year old son provided a total of 18 months of labor for all 5 sizes of dairy herds. It was assumed that hired labor was unionized and milked 75, 80, or 90 cows twice daily at monthly rates specified in Table 3. The operator did all the milking for alternative A1 and for alternative A2 would milk cows one day a week since union labor is employed on a six-day work week. The labor required for Plan A3 with 110 cows included a full-time milker and relief milkers hired for 52 days on the basis of $23 to $25 per day depending on the number of cows milked.

For Plan A4 with 170 cows, the total hired labor force included two full-time milkers plus relief milkers hired for 104 days. Two full-time milkers, plus one full-time man to feed and clean yards, and relief milkers for 104 days was the hired labor force for the 225 cow alternative (A5). For the 335 cow herd, the hired labor force included 3 full-time milkers, one full-time relief milker, and a full-time man to feed forage and perform other barnyard chores.

It was assumed that cows were milked in shifts in stanchion barns equipped with pipeline milking equipment. For example, each of the two milkers for the 225 cow herd would milk three strings of 30 cows each on one side of a 60-stanchion barn. Each milker would bring in and wash the cows, feed concentrates and milk his three strings of cows. A second and third crew of milkers might utilize the stanchions after the first crew completed the milking process. This is one method of reducing barn and milking equipment costs per cow when size of herd is increased.

Dairy housing

Housing would not be required for the milking herd. Hay would be stored in hay barns in a central location and fed in bunks at the perimeter of the lots. Silage and green chopped material would also be fed in these bunks. Lots would be cleaned periodically either through the efforts of the dairymen's own manure cooperatives or by contract operations. In Dairy Valley, 60 percent of the cows are included in "The Dairymen's Fertilizer Cooperative, Inc."

Feed inputs and milk output

Milk production and feed requirements per cow were based on Holsteins with milk sales of 12,300 pounds 3.6 percent butterfat. This is the present average sales per cow in the Chino-Ontario and other areas adjacent to the metropolitan Los Angeles market area.

For these dry-lot dairy cows, annual feed included 6 tons of hay and 5,000 pounds of concentrates (Table 2). Some dairymen feed either green-chopped material or silage as a substitute for part of the hay, but this would not alter the total tons of hay equivalent fed per year.

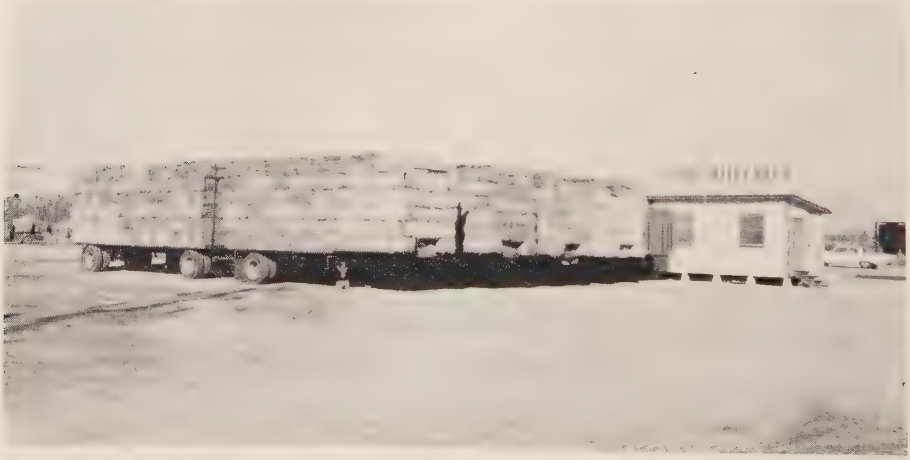

Fig. 2. Availability of large quantities of high quality alfalfa hay has contributed to the development of dry-lot dairying in Southern California.

Inputs and Performance Rates For Michigan

Labor and equipment

It was assumed that the operator and a 17-year old son would provide 18 months of labor. For the Michigan dry-lot dairy alterna-

tive B, the labor requirements for the 65 and 110 cow herds were calculated to be essentially the same as for the two smaller sizes of herds in California. It was estimated that the labor requirements for the 170 and 225 cow herds were somewhat greater for Michigan than for California.

The acres of land needed and the months of labor required for alternatives B, C, and D are shown in Table 1. All feed was purchased for the five alternatives under B. For alternatives C and D Plans 1, 2, and 3 provided for the production of all forage and grain, but for Plans 4 and 5 all forage was grown and all concentrates were purchased.

Housing and feeding

Budgets provided for new investments in loose-housing barns, herringbone milking systems and year around storage feeding for all alternatives studied. Hay was stored and fed from a hay barn. Silage was stored in concrete stave tower silos and mechanically augered into feeding bunks.

Feed inputs and milk output

The Michigan budgets included Holstein cows with milk sales of 10,000, 11,000, and 12,000 pounds of 3.6 percent butter fat test. These represent current ranges in average milk sales per farm on the better managed dairy farms. Very few commercial herds of 100 or more cows would average more than 10,000 or 11,000 pounds milk sold per cow.

The feed inputs for the Michigan dry-lot budgets included 3.7 tons of hay and 10 tons of silage, or a total of 7.0 tons of hay equivalent and 3,100 pounds of grain when dairy sales per cow were 10,000 pounds of milk. An additional 500 pounds of concentrates were included when milk sales were 11,000 pounds. Pounds of concentrates were increased to 4,200 when milk sales were 12,000 pounds per cow. Part of the increased sales per cow were also due to a 3 percent greater culling rate assumed for each increase of 1,000 pounds of milk sold and to better management practices.

The annual requirements of 3.7 tons of hay and 10 tons silage were based on feeding about 50 percent of the forage as hay and 50 percent as silage (Table 2). Other combinations, including up to 75 percent silage and 25 percent hay, could also be used with about equal results. The feed inputs per cow for alternative D where all

replacements were grown included 6.3 tons of hay and 12.0 tons of silage for a total of 10.3 tons of hay equivalent per cow per year plus 3,450 pounds of grain for the 10,000 pounds milk sales per cow. These feed inputs were increased to 10.6 tons of hay equivalents and 4,000 pounds of concentrates for the 11,000 pounds of milk sales per cow.

TABLE 2—Pounds milk sold, rate of culling and feed inputs per cow, Southern California and Southern Michigan

Annual rate	Southern California	Southern Michigan					
		Buy replacements			Grow replacements		
Milk sales per cow lbs.(a)	12,300	10,000	11,000	12,000	10,000	11,000	12,000
Rate of culling percent(b)	37.0	25.0	28.0	31.0	25.0	28.0	31.0
Feed per cow(c)							
Hay, tons	6.0	3.7	3.7	3.7	6.3	6.5	6.7
Silage, tons	....	10.0	10.0	10.0	12.0	12.3	12.9
Total hay equivalent, tons	6.0	7.0	7.0	7.0	10.3	10.6	11.0
Concentrates, lbs.	5,000	3,100	3,600	4,200	3,450	4,000	4,600

(a) 3.6 percent butterfat.
(b) Includes 2% death loss of cows.
(c) Quantities fed, but not necessarily consumed. Data for Michigan based on 50 percent hay and 50 percent silage ration for cows and less silage for replacement heifers. California data based on records from Bureau of Milk Control, State of California.

Price and Cost Prospects

The prices assumed for the California and Michigan budgets as shown in Table 3 are based largely on 1960 price levels with some adjustments made for expected changes during the next 2 to 5 years. The net farm price for 3.6 percent test milk was $5.25 for Southern California and $4.00 for Southern Michigan. Sale of cull cows was estimated at $190 per head in Southern California and $180 in Southern Michigan. The purchase price of herd replacements was assumed to be $340 for Southern California when milk sales per cow are 12,300 pounds. For Michigan, replacement costs of $325, $300 and $290 were assumed for cows with milk sales 12,000, 11,000 and 10,000 pounds, respectively.[3]

The percent of cows culled is closely related to the price of

[3] Cost of replacements for California based on reports from auctions, and for Michigan based on prices paid at private sale by dairymen.

TABLE 3—Prices assumed for California and Michigan budgets

Item	Unit	California		Michigan	
		Prices received	Prices paid	Prices received	Prices paid
		dollars	dollars	dollars	dollars
Milk, 3.6% b.f.(*a*)	cwt.	5.25		4.00	
Cull cows (Holstein)	each	190.00		180.00	
Herd replacements					
Pounds milk sold per cow					
12,300	each		340.00		
12,000	each				325.00
11,000	each				300.00
10,000	each				290.00
Corn	bushel			1.00	1.10
Soybean meal	cwt.				4.00
Grain mixture (concentrate)	ton		60.00		45.00
Alfalfa hay, baled(*b*)	ton		32.00		24.00
Land					
25 acres or less	acre		2,500.00		800.00
100 acres or more	acre				400.00
Hired labor					
Milking by pipeline(*c*)					
75 cows	month		450.00		330.00
80 cows	month		480.00		355.00
90 cows	month		530.00		380.00
75 cows	day		32.00		17.00
90 cows	day		25.00		18.00
Other labor	month		400.00		300.00

(*a*) Net price at farm, after deducting hauling.
(*b*) Includes cost of delivery.
(*c*) For California, milkers provide own housing, and for Michigan, labor rates include cost of housing and perquisites furnished. Based on 6 day working week for California and 6½ day week for Michigan.

beef. In more recent years the culling rate on Southern California farms has been somewhere between 30 and 40 percent as reported by the Bureau of Milk Stabilization.

Concentrates were priced at $45 and hay at $24 per ton for the Southern Michigan budgets. The prices for concentrates and alfalfa hay were about a third higher for Southern California. Land was priced at $2,500 per acre for Southern California, and $800 per acre for acreages below 25 and $400 for acreages of 100 or more in Southern Michigan. This assumes level, highly productive soil capable of producing 3.8 tons of hay, 95 bushels of corn for grain, and 16 tons silage per acre annually.

The labor wages assumed in the budget are the current ones for California and the Michigan wage rate somewhat higher than present

ones. The monthly wage rates for milkers in California would be increased by $70 when a pipeline system was not used. The California rates are based on a six-day working week, but do not include housing, milk or other perquisites quite often furnished to Michigan laborers. The Michigan rates include a value placed on these perquisites.

Depreciation and repairs for buildings, equipment, tractors, and farm machinery, were calculated on the basis of generally accepted rates for these investments.[4] Taxes on real estate, buildings, and equipment were calculated on the basis of rates charged in Southern California Counties. Taxes on cows were calculated at $8.00 per head. A miscellaneous dairy charge of $20 per cow included dairy herd testing, breeding, veterinary and medicine, and other general dairy costs.

An indebtedness of 40 percent was assumed for the 75 cow operation in Southern California. An interest rate of 6 percent was used. For the other three herd sizes, interest was also charged on 40 percent of the investment plus the additional investment above the 75 cow operation.

COMPARATIVE INVESTMENTS

California Dry-lot Dairying

A. Buying the feed and replacements

Investments in land, buildings, equipment, yards, cows, and feed were calculated for the five dairy herd sizes in Southern California as shown in Table 4. These are based on new costs at 1960 price levels.[5] [6]

Total investment for land, buildings, equipment, corrals, and water and sewage systems was nearly $56,000 for the 75 cow herd or an average of $746 per cow (Table 4). The investment per cow was reduced to $628 for the 110 cow herd and $480 for the 170 cow operation. The investments per cow were reduced by smaller percentages for the herds larger than 170 cows. Pipeline milking systems were included for all of the 5 herd sizes, since this would permit greater economy in use of hired labor. Pipeline milking systems in stanchion barns are more economical in California than in Michigan since one stanchion is generally used 2 to 6 times during the milking period.

[4] Report by Frazer and Torbet (1959). Cost of Producing Market Milk in the Los Angeles Metropolitan Milkshed, Milk Producers Council.

[5] Fletcher, L. B. (1960). Growth and Adjustments of the Los Angeles Milkshed: A Study of the Economics of Location. Ph.D Thesis, University of California.

[6] Report AH 537.7, State Board of Equilizations (1958). Farm Improvement Costs, California.

TABLE 4—Estimated investment in land, buildings, equipment, yards, cows and feed. Five dairy herd sizes, Southern California(a)

A. Buy feed and replacements

Items	Alternative plans				
	1 and 2	3	4	5	6
	dollars	dollars	dollars	dollars	dollars
Land	25,000	30,000	35,000	45,000	60,000
Milking plant(b)	9,000	10,100	12,960	19,200	26,800
Milking equipment(c)	8,660	12,260	13,670	16,200	23,400
Hay and hospital barns	5,400	7,600	9,300	12,200	16,000
Corrals, water and sewage system & miscellaneous(d)	7,900	9,100	10,500	12,200	16,000
Total land, buildings and equipment	55,960	69,060	81,430	104,800	142,200
Cows	18,750	27,500	42,500	56,250	83,750
Feed	11,000	16,000	26,000	35,000	52,000
Total investment	85,710	112,560	149,930	196,050	277,950

(a) 1960 acquisition and building costs.
(b) Milking plant includes milking barn, stanchions, milk and equipment room, bulk concentrate tank, and holding areas.
(c) Includes milkers, pipeline, compressor and pump, bulk tank, water heater, wash tanks, etc.
(d) Includes pick-up truck and other equipment.

Fig. 3. The growing of replacement heifers is a specialized enterprise on this farm in the San Joaquin Valley of California.

Total investments, including cows and feed, ranged from $1,140 per cow for the 75 cow herd to $830 for the 335 cow unit. This investment per cow was reduced by only $40 per cow as the size of herd increased from 225 to 335 cows.

Michigan Dairy Farm Alternatives

B. Buying the feed and replacements

Investments in land, housing, milking plant, equipment, hay and silage storage, concrete yards, and water and sewage systems totalled about 80 percent as high for Southern Michigan as for California. A considerably lower investment in land is the reason for this reduced total investment in land, buildings, and equipment. Investment in the milking and milking plant, barns, feed storage facilities, concrete yards, and water and sewage systems average nearly $50 more per cow for the 170 cow operation and about $15 more per cow for the 225 cow operation for Michigan than for California. Total investment figures for the four Southern Michigan dry-lot dairy alternatives are shown in Table 5.

TABLE 5—Estimated investments in land, buildings, equipment, yards, cows and feed, Southern Michigan(a)

B. Buy feed and replacements

	Alternative plans			
	1 and 2	3	4	5
	dollars	dollars	dollars	dollars
Land	9,600	12,000	15,200	19,200
Milking plant	4,900	5,200	5,800	6,200
Milking equipment	6,200	7,550	9,600	11,100
Loafing and hospital barn	4,300	7,000	10,250	13,300
Hay barns	2,400	3,200	4,800	6,000
Granary and machine sheds	3,500	4,500	5,000	5,500
Silos, mechanical unloaders and feeders	6,500	10,800	10,800	10,800
Concrete areas and fences	2,000	3,300	5,200	6,800
Water and sewage systems	2,200	2,500	2,800	3,200
Total land, buildings and equipment	41,600	56,050	69,450	82,100
Tractor, truck and manure equipment	5,300	5,300	6,800	6,800
Cows	16,250	27,500	42,500	56,250
Feed	7,750	10,550	16,300	21,500
Total investment	70,900	99,400	135,050	166,650

(a) 1960 acquisition and building costs.

C. Growing the feed and buying replacements

The alternative of growing all or most of the feed but buying the replacements adds considerably to the investment, Table 6. The investment in land, buildings, feed storage facilities, and equipment would average about $1,500 per cow for the 65 cow herd and $1,150 for the 225 cow herd. This is more than 2½ times as much as investments for the dry-lot dairy alternatives. Power, machinery and equipment to operate the cropland also add to the investment. Total investment for the 65 cow herd would average $2,260 per cow compared to about $1,500 for the 225 cow operation.

TABLE 6—Estimated investment in land, buildings, equipment, yards, cows and feed, Southern Michigan

C. Grow feed and buy replacements(*a*)

	Alternative plans				
	1	2	3	4	5
	dollars	dollars	dollars	dollars	dollars
Land	65,500	65,500	110,000	119,800	174,500
Milking plant	4,900	4,900	5,200	5,800	6,200
Milking equipment	6,200	6,200	7,550	9,600	11,100
Loafing and hospital barns	4,300	4,300	7,000	10,250	13,300
Hay barns	2,150	2,150	3,200	4,400	6,000
Granary and machine shed	5,500	5,500	6,300	6,700	7,500
Silos, mechanical unloaders and feeders	6,500	6,500	10,800	20,600	25,900
Concrete areas, fences	2,000	2,000	3,300	5,200	6,800
Water and sewage systems	2,200	2,200	2,500	2,800	3,200
Total land, buildings and equipment	99,250	99,250	155,850	185,150	254,500
Tractors and truck	9,200	9,200	10,000	12,500	12,500
Machinery and equipment	14,300	10,200	15,300	18,450	18,700
Cows	16,250	16,250	27,500	42,500	56,250
Feed	7,750	7,750	10,550	16,300	21,500
Total investment	146,750	142,650	219,200	274,900	363,450

(*a*) Grow all feed for alternatives 1, 2, and 3 and buy grain for alternatives 4 and 5.

D. Growing both feed and replacements

The alternative of growing both feed and replacements would bring investment per cow to a total of $2,750 for the 65 cow herd and about $2,100 for the 170 and 225 cow herds, Table 7. The last two alternatives include only enough land to produce the hay, pasture

and silage requirements for the cows and replacement heifers. The alternatives D4 and D5 of growing the replacements rather than buying them added about 30 percent to total investments. For the three smaller herd sizes, investments were increased by 20 percent.

TABLE 7—Estimated investment in land, buildings, equipment, yards, cows and feed, Southern Michigan

D. Grow feed and replacements(*a*)

	Alternative plans				
	1	2	3	4	5
	dollars	dollars	dollars	dollars	dollars
Land	90,400	90,400	137,200	182,000	264,000
Milking plant	4,400	4,400	4,400	5,200	5,200
Milking equipment	6,000	6,000	7,200	8,900	10,500
Loafing and hospital barns	5,900	5,900	9,500	13,700	17,500
Hay barns	2,150	2,150	3,200	4,400	6,000
Granary and machine shed	6,000	6,000	7,000	7,500	8,000
Silos, mechanical unloaders and feeders	6,500	6,500	15,800	24,800	25,900
Concrete areas	2,000	2,000	3,300	5,200	6,800
Water and sewage systems	2,200	2,200	2,500	2,800	3,200
Total land, buildings and equipment	125,550	125,550	190,100	254,500	347,100
Tractors and truck	9,500	9,500	11,500	12,500	14,500
Machinery and equipment	15,200	11,100	15,300	18,400	18,900
Cows	19,500	19,500	33,000	51,000	67,500
Feed	7,750	7,750	10,550	16,300	21,500
Total investment	177,400	173,400	260,450	352,700	469,500

(*a*) Grow all feed for alternatives 1, 2, and 3 and buy grain for alternatives 4 and 5.

COMPARATIVE INCOME PROSPECTS

California Dry-Lot Dairying

A. Buying the feed and replacements

Receipts, including the sale of milk, cull cows, and calves, were calculated for the 6 alternatives for Southern California. A culling rate of 37 percent was assumed. The percent of cows culled annually ranged from 20 to nearly 100 percent for individual herds studied.

The net income for Plan A1 for the 75 cow herd and no full-time hired labor was nearly $10,000 (Table 8). This would be considered

TABLE 8—Estimated receipts, expenses and net income, five alternative herd sizes Southern California, 12,300 pounds milk sold per cow, 1960 prices

A. Buy feed and replacements

	Alternative plans					
	1	2	3	4	5	6
	dollars	dollars	dollars	dollars	dollars	dollars
Receipts						
Milk	49,815	49,815	73,062	112,914	149,445	222,507
Cull cows and calves	6,012	6,012	8,994	13,848	18,210	27,030
Totals	55,827	55,827	82,056	126,762	167,655	249,537
Expenses						
Feed	25,680	25,680	37,620	58,140	76,920	114,540
Replacements	9,520	9,520	13,940	21,420	28,560	42,460
Hired labor	1,325	5,886	8,350	14,606	19,649	31,915
Depreciation and repairs						
Buildings and equipment	1,881	1,881	2,271	3,052	3,765	5,250
Power and machinery	300	300	300	320	340	370
Taxes and insurance	1,906	1,906	2,473	3,481	4,446	6,247
Utilities	610	610	870	1,190	1,462	2,175
Milk hauling	1,383	1,383	2,030	3,137	4,151	6,180
Miscellaneous dairy	1,500	1,500	2,200	3,400	4,500	6,700
Interest	1,770	1,770	3,078	4,940	7,198	10,206
Totals	45,875	50,436	73,132	113,686	150,991	226,043
Net income	9,952	5,391	8,924	13,076	16,664	23,494

a reasonably satisfactory net income in the dry-lot dairy areas of California. When a full-time milker was hired for the 75 cow operation, the net income was reduced to $5,400 or only slightly more than half of what it would be with the operation largely a family labor situation. The $5,400 net would be less than what the full-time milker would be earning.

Net income for alternative Plan A3, with 110 cows, would be about $1,000 less than for Plan A1. However, for many operators this would be a much more desirable situation because the operator and his family would not be tied down in doing all of the chores as well as managing the operation.

On the basis of the assumptions made relative to production per cow and prices received and paid, it appears profitable for Southern California dairy farmers to expand to 170, 225, and 335 cow dry-lot dairy farms. This, of course, assumes that the manager is capable of

operating these larger units and that a high percent of the milk produced is sold at Class 1 price.

The effect of a reduction of $0.25 in the price received for 100 pounds of milk is shown for the 5 herd sizes in Figure 4. It would be considerably less profitable to increase herd size to the larger units with this reduction in price.

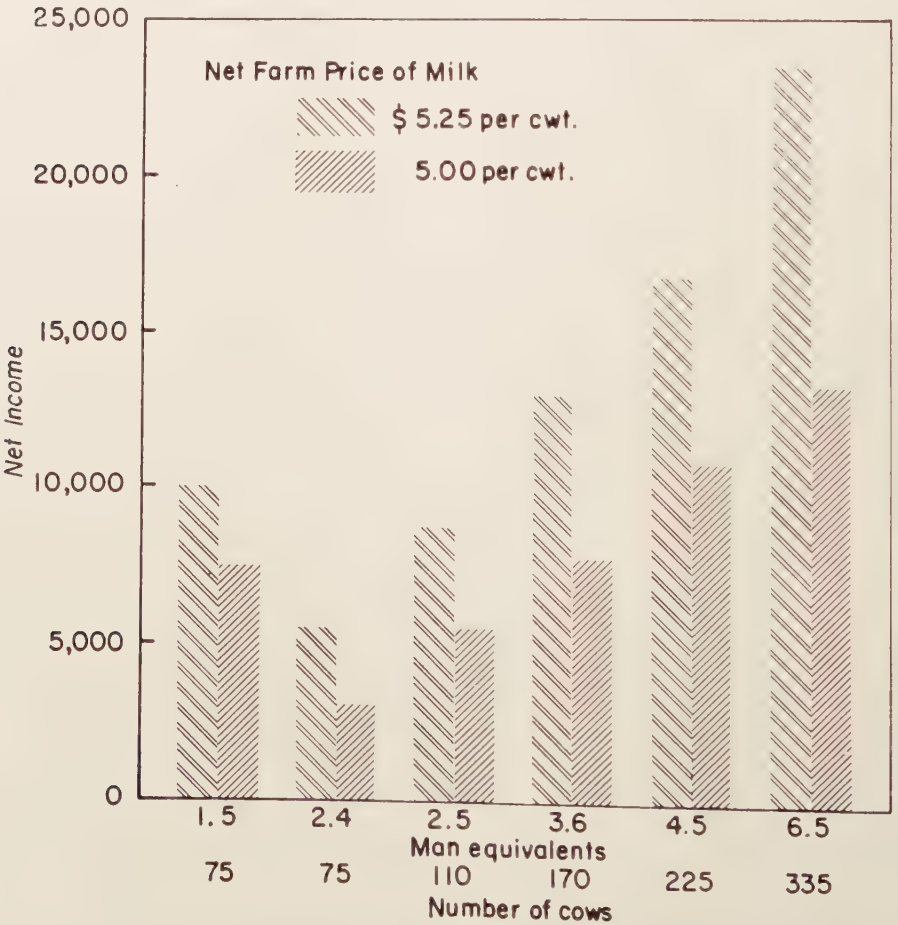

Fig. 4. Net farm income, buy all feed and replacements, five sizes of dairy herds and two levels of prices for milk, Southern California.

California dairymen often expand herd size above the quantity of milk which can be sold at Class 1 price with the hope that contracts may, sometime in the future, be increased to cover the added production. An individual dairyman may have a lower net income, at least

in the short-run, from the expanded operation. Suppose that we assume that the dairyman budgeted had a contract for 7,000 pounds of milk sold daily. This would be slightly higher than for the 170 cow dairy operation. If this dairyman expanded to a 225 cow operation and sold most of the additional milk at the Grade B price of about $3.35 per cwt., his net income would be lowered by nearly $1,300. If he expanded to a 335 cow operation, the result would be total expenses exceeding receipts by nearly $12,000.

Michigan Dairy Farm Alternatives

B. Buying the feed and replacements

Receipts and expenses for the four herd sizes in Southern Michigan were calculated on the same basis as those for the Southern California farms. With milk sales of 10,000 pounds per cow and $4.00 net per cwt. for 3.6 percent test milk, the alternative of buying all feed and replacements under Plan B1 for the 65 cow herd resulted in a net income of $2,000 (Table 9), or only one-fifth as much as for California Plan A1

TABLE 9—Estimated receipts, expenses and net income, four alternative herd sizes Southern Michigan, 10,000 pounds milk sold per cow

B. Buy all feed and replacements

	Alternative plans				
	1	2	3	4	5
	dollars	dollars	dollars	dollars	dollars
Receipts					
Milk	26,000	26,000	44,000	68,000	90,000
Cull cows and calves	3,660	3,660	6,182	9,570	12,780
Totals	29,660	29,660	50,182	77,570	102,780
Expenses					
Feed	15,088	15,088	25,417	39,401	52,135
Replacements	4,930	4,930	8,510	13,050	17,690
Hired labor	625	3,960	5,340	11,520	15,720
Depreciation and repairs					
Buildings and equipment	2,357	2,357	3,174	3,861	4,444
Power and machinery	675	675	715	930	970
Taxes and insurance	566	566	750	955	1,112
Utilities	585	585	825	1,120	1,440
Miscellaneous dairy	1,625	1,625	2,750	4,250	5,625
Interest	1,191	1,191	2,500	4,178	5,716
Totals	27,642	30,977	49,981	79,265	104,852
Net income	2,018	−1,317	201	−1,695	−2,072

with 75 cows and milk sales of 12,300 pounds per cow. Hiring a full-time milker for the 65-cow alternative resulted in a loss of $1,317. A loss in net income resulted from the adoption of dry-lot dairying to herds of 170 and 225 cows (Figure 5).

Increasing milk sales to 11,000 added substantially to net income but not enough to make the alternative of buying all feed and replacements attractive to dairymen. A further increase in milk sales to 12,000 pounds per cow but at the same $4.00 net farm price for 100 pounds of milk would not encourage dairymen to adopt this alternative (Figure 5).

The effect of adding $0.25 to the price received for 100 pounds of milk was calculated for the 5 Michigan alternatives and at the same three levels of milk sales (Fig. 6). When milk sales were 12,000 pounds per cow, the alternative of buying feed and replacements would be sufficiently profitable to encourage adoption of this alternative and an expansion of herd size. With milk sales of 10,000 pounds per cow this alternative would be unprofitable.

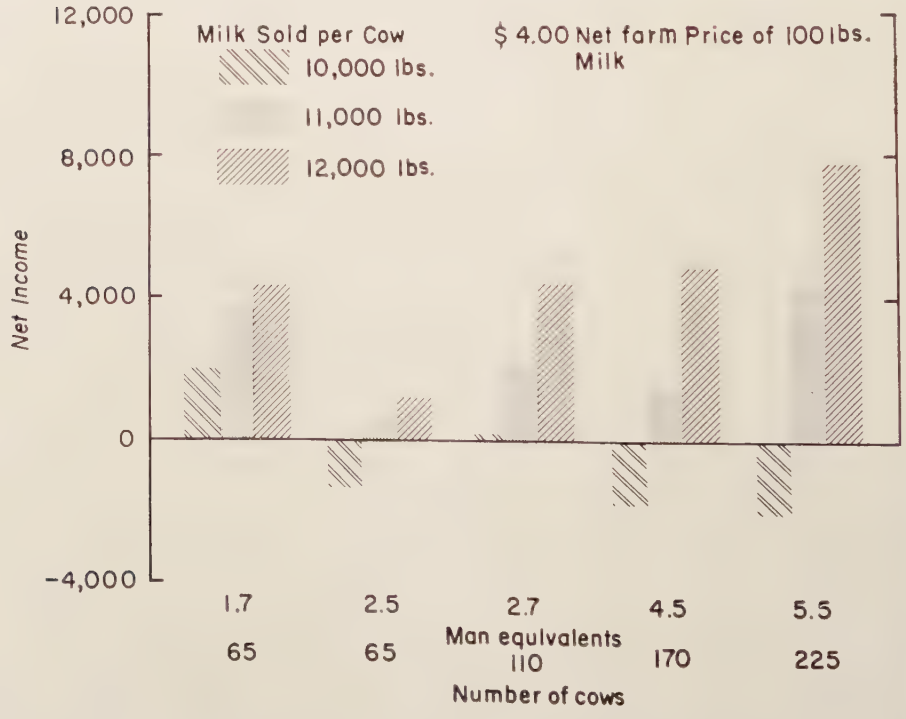

Fig. 5. Net farm income, buy all feed and replacements, four sizes of dairy herds and two levels of milk production, net farm price of milk at $4.00 per cwt.

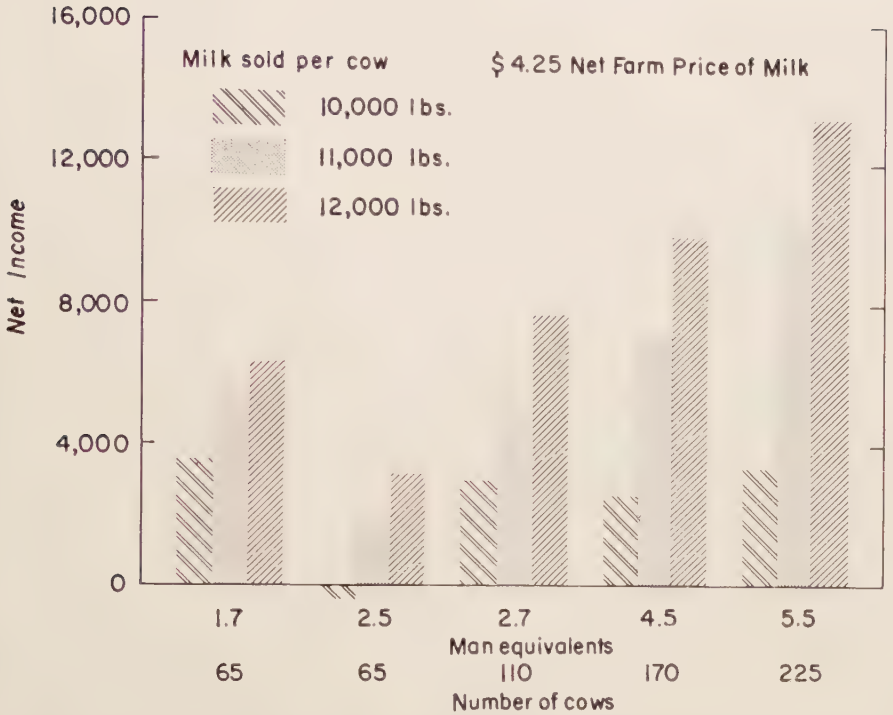

Fig. 6. Net farm income, buy all feed and replacements, four sizes of dairy herds and three levels of milk sales per cow, net farm price of milk at $4.25 per cwt., Southern Michigan.

C. Growing the feed and buying replacements

The economic consequences of growing the feed and buying the replacements were also calculated for the 4 herd sizes, and for the 10,000 and 11,000 pounds of milk sales per cow. Additional costs of seed, fertilizer, lime, fuel, oil, custom work, and depreciation and repairs on the additional power and machinery were more than offset by savings in feed purchases. Protein supplement was the only feed purchased for the 65 and 110 cow operations, with all of the grain also purchased for the 170 and 225 cow operation.

The net income for Plan C1 where the operator and his son milked and cared for the 65 cow herd, was $6,200 (Figure 7). The hiring of a full-time milker reduced this to $4,000 which again is less than what the hired labor would receive. Moderate increases in net income resulted for the 110, 170, and 225 cow operations with milk sales of 10,000 pounds per cow. The alternative of growing the feed and

buying the replacements was fairly attractive when milk sales totaled 11,000 pounds per cow (Figure 7.)

These increases in net income resulting from expansion in herd size would not occur if milk production per cow was substantially reduced or if the base quantity sold for fluid use was not increased in proportion to the number of cows added.

Fig. 7. Net farm income, grow feed and buy replacements, four sizes of dairy herds and two levels of milk sales per cow, net farm price of milk at $4.00 cwt., Southern Michigan.

D. Growing the feed and replacements

Alternative D1 of growing both the feed and replacements for the 65 cow herd resulted in a gain in net income of 25 percent over alternative C1 where the replacements were purchased (Table 10). For the herd sizes of 110, 170, and 225 and milk sales at 10,000 pounds per cow, net income was increased 40 to 50 percent by growing rather

than purchasing the replacements. The validity of these relationships depends largely on the assumptions regarding the labor requirements for alternatives C and D. Growing replacements on farms with the herd sizes budgeted require only part of a man's time. Therefore, labor can often be used to better advantage when the replacements are grown rather than purchased. On other farms, the reverse may be true. The price relationship between cull cows and replacements also has an important effect on the income differences between Plans C and D.

When pounds of milk sold per cow is assumed at 11,000, the alternative of growing both feed and replacements becomes especially profitable for the larger herds (Figure 8). Reduction in yields or quality of feed crops harvested would substantially reduce these net income figures.

TABLE 10—Estimated receipts, expenses and net income four alternative herd sizes Southern Michigan, highly productive soils, 10,000 pounds milk sold per cow

D. Grow feed and replacements

	Alternative plans				
	1	2	3	4	5
	dollars	dollars	dollars	dollars	dollars
Receipts					
Milk	26,000	26,000	44,000	68,000	90,000
Cull cows and calves	3,660	3,660	6,182	9,570	12,780
Totals	29,660	29,660	50,182	77,570	102,780
Expenses					
Seed, fertilizer and lime	2,719	2,719	4,731	4,982	7,602
Fuel, oil and custom hire	1,697	1,217	1,904	2,633	4,360
Feed	1,168	1,168	1,980	11,090	14,682
Replacements	.....	.....	.....	.....	.....
Hired labor	3,600	5,460	10,860	17,820	22,920
Depreciation and repairs					
Buildings and equipment	2,564	2,564	3,876	5,307	6,132
Power and machinery	2,883	3,691	4,054	4,566	4,481
Taxes and insurance	1,430	1,430	2,158	2,883	3,952
Utilities	585	585	825	1,120	1,400
Miscellaneous dairy	1,625	1,625	2,750	4,250	5,625
Interest	3,531	3,566	8,055	12,915	19,648
Totals	21,802	24,025	41,193	67,566	90,802
Net income	7,858	5,635	8,989	10,004	11,978

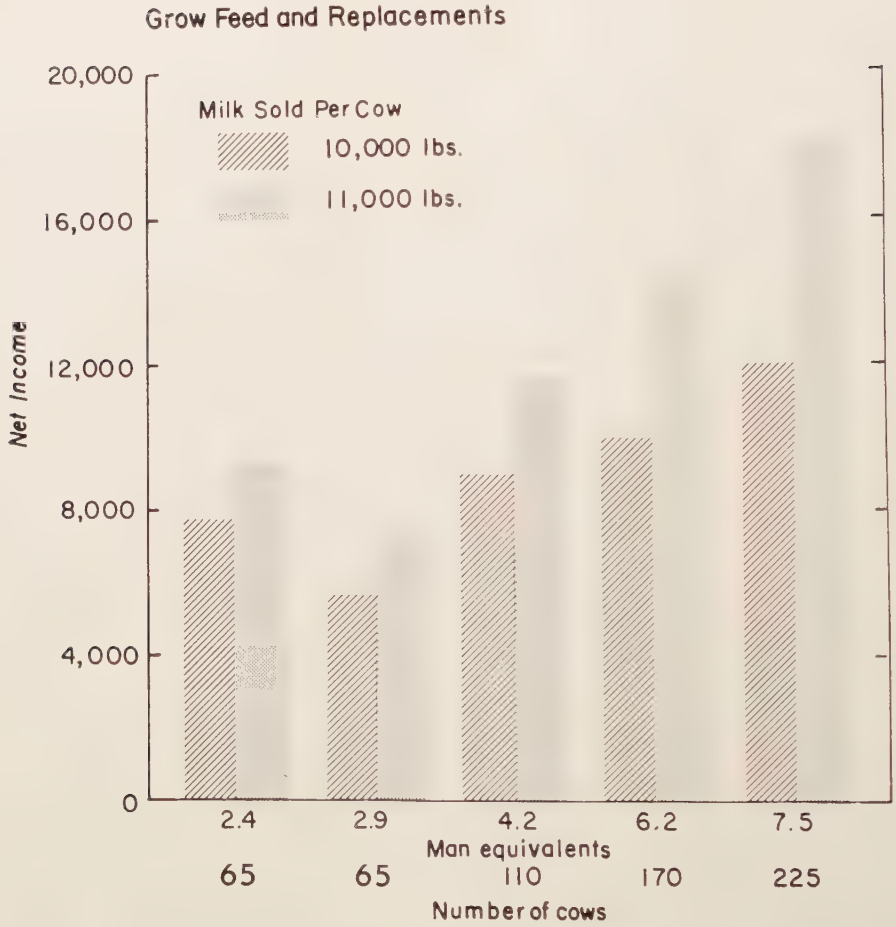

Fig. 8. Net farm income, grow feed and replacements, four sizes of dairy herds and two levels of milk sales per cow, net farm price of milk at $4.00 cwt.

FUTURE IMPLICATIONS

Whether it will become profitable for Michigan dairy farmers to move in the direction of dry-lot dairying and large-scale operations will depend largely on the relationship of prices received for milk and the cost of land, labor, feed, and other inputs. Government price and production programs could have a considerable effect on these relationships. A quota or contract system accompanied by fixed minimum prices for milk would also affect the profitability of dry-lot dairy farming. Whether dairymen operate under a contract system

similar to that in California or on a base and surplus system, as is the situation in Michigan, dairy farm profits will depend on selling a high proportion of the milk at Class 1 prices.

Increased competition for land is expected to increase land values and tax rates, especially in areas adjoining metropolitan areas. This could have the effect of either driving dairy farmers out of these highly competitive land areas if milk prices were not high enough to cover the additional costs or dairy farmers would tend to limit the land needed for dry-lot operations plus possibly some land for the production of silage and other forage crops. Increased urban developments throughout Michigan could result in higher tax assessments and rates on agricultural land adjoining new housing and commercial areas.

As a guide in selecting profitable dairy alternatives, individual dairymen will need to calculate the expected changes in receipts and expenses before increasing size of herd or changing the method of obtaining additional feed and herd replacements. To achieve success in dry-lot dairying under the more favorable price relationships, a dairyman will need the following qualifications:[7]

[7] Personal comments from C. O. McCorkle, Jr., University of California.

Fig. 9. Most Michigan dairy men will find it profitable to grow part or all of their silage and hay requirements and if necessary to buy grain.

(1) Ability to organize, finance and operate large-scale businesses.
(2) Ability to bargain. Must be skilled in knowing how much to pay for feed and replacements in relationship to their relative values.
(3) Need of attaining a high level of internal efficiency.

The problems in organizing and operating a dairy farm where all feed and replacements are purchased are vastly different from a farm where all or most of the feed and replacements are produced on the farm. There is the problem of locating sources of feed and herd replacements. In California, regular markets have been established for hay and dairy replacements. There are no such markets in Michigan. The quantities of hay produced for sale are quite limited in the State.

Recruiting of dairy labor would be a major problem in general farming areas. Highly satisfactory dairy labor appears to be available in the concentrated dairy areas of California. Most Michigan dairymen will need to change their philosophy regarding labor policies, wage rates and performance rates if they are to obtain skilled milkers.

Investments in land, buildings, and equipment for dry-lot dairy farms cannot be recovered from added income unless dairymen net more than $4.00 per cwt. of 3.6 percent milk sold and sell more than 12,000 pounds of milk per cow. These dairymen must be skilled in dealing with hired labor, feed merchants, and dairy replacement dealers. They must also be successful in organizing the most economical combination of labor and number of cows.

HEATING RATES IN GLASS CONTAINERS AS AFFECTED BY HEATING MEDIUM AND PRODUCT

By I. J. PFLUG and R. C. NICHOLAS
FOOD SCIENCE DEPARTMENT

GIVEN THE AMOUNT of heat necessary to preserve a product, the processing system may be designed to achieve this heat level. Since sterilization or pasteurization of food products is accomplished during non-steady flow of heat into the container and product, generally the problem is one of obtaining maximum temperature in a minimum time at minimum cost. Therefore, detailed knowledge of the heat transfer characteristics of the system is a necessary ingredient of efficient design.

This study treats factors affecting the heat transfer coefficient between heating medium and container. The purpose is to compare several heating media—water spray, steam-air mixtures, water bath, and saturated steam—at temperatures in a range of 165°F. to 225°F. in two sizes of glass containers (pints and quarts) for two primary methods of heating; namely, conduction and convection.

Townsend *et al.* (6) investigated the properties of 1 percent bentonite (convection heating) and 5 percent bentonite (conduction heating) heated in saturated steam and in water at temperatures of 240°F. and 250°F. in various sizes of both tin and glass containers. Their principal objective in this thorough study was the comparison of glass with tin. They found no significant differences between steam and water. They observed appreciably slower heating by convection in glass compared with tin, but a less pronounced difference in conduction heating for all sizes of containers compared.

Powers *et al.* (5) extended the available information on glass to comparisons between convection and conduction heating (also 1 percent and 5 percent bentonite) in both pints and quarts at 212°F. for steam and water. They found no significant differences between the heating media.

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Esselen *et al.* (2) compared water spray and water bath heating (temperatures in the range 170°F. to 185°F.) of whole fresh packed pickles and found that heating rates were essentially the same for these two media.

This study, therefore, covers the uncharted region of steam-air mixtures below 212°F. and compares this heating medium with some already investigated.

EXPERIMENTAL

The simple systems of water and of 5 percent bentonite, representative of convection and conduction heating, were selected as exemplifying the product extremes encountered in food processing. The water was taken from the laboratory tap; the bentonite (1) was made up as 5 percent clay, by weight, of the suspension (Volclay Micron Bentonite, USP Bentonite, American Colloid Company). Temperatures were measured with 24-gauge copper-constantan thermocouples introduced into the top of the jars, through suitable pressure fittings, inside rigid ¼″ plastic rods; temperatures were measured and recorded with a Minneapolis-Honeywell 12-point 1-min. cycle (smallest chart division 1°F.)temperature recording potentiometer. Table 1 gives the technical description of the jars used. When temperatures were measured in bentonite, the thermocouple junction was located at the geometrical center of the jars; when measurements were made in water, the junction was located 1.0 cm. from the bottom of the pint jars and 1.5 cm. from the bottom of the quart jars. These locations are in the vicinity of the slowest heating points in these two jars, as determined from heating rate profiles made at points along the jar axes from top to bottom.

All the jars were started at an initially uniform inside temperature of 95°F.—obtained by allowing the jars to equilibrate in a constant temperature bath prior to testing.

TABLE 1—Data on containers used in study

	Jars	
	Pint	Quart
Capacity (oz.)	16	32
Outside diameter (in.)	3⅛	3¾
Height to finish (in.)	4¼	6½
Overflow capacity (oz)	16½	33
Weight of glass (lb.)	0.45	0.84

Water Bath

The water bath used in these studies was a rectangular, uninsulated steel tank, 24 x 48 x 15 inches: a 12 in. water depth was maintained. It was steam heated by a ¾ in. pipe coil in the bottom of the tank. The temperature in the water bath was controlled by a Taylor Model 87RU417 temperature controller modulating a valve in the steam line. A pressure reducing valve permitted adjustment of the up-stream steam pressure to give optimum control. The water was agitated by a Lightening Model L electric mixer with shaft in a vertical plane; the jars were in general located from 10 to 18 inches from the 2-in. diameter, 3-blade propeller, which was 9 in. below the water surface.

Point-to-point temperature variation in this bath was less than 1.25°F. and the standard deviation of the variation at any one point was about 0.25°F.

Water Spray

The water spray tests were conducted in a loosely closed, vertical, laboratory retort, which was modified for these tests by the addition of an external pump and seven spray nozzles located a few inches below the cover. The bottom 6 in. of the retort served as a reservoir for the temperature controlled recirculated water. The tops of the jars were about 9 in. below the nozzles. It was found that by maintaining the water in the reservoir at about 1.5 to 2.0°F. above the desired spray temperature, the spray temperature could be kept at the desired mean with a variation of about 1.0 F. Point-to-point variation in the spray was no more than 2.0°F.

Saturated Steam

The heating rate of quart jars of water was evaluated at 165, 180, 195, 210 and 225°F. in saturated steam. The laboratory retort previously described was used in these experiments and was equipped with an external condensing chamber, tail pipe and pump plus a gas pump for removing non-condensables. This system had sufficient capacity to maintain a vacuum of 22 in. of mercury in the retort when operating at a low flow rate at 150°F. In heating rate studies, the temperature equilibrated jars were placed in the retort, which was sealed and evacuated prior to turning on the steam. The by-pass around the control valve was opened during the come-up period to reduce come-up time which was less than 1 minute and was neglected in calculating

f_h and j. The point-to-point temperature variation was less than 1.0° F. and the variation at any given point was less than 0.5°F.

Steam-air Mixtures

These tests were of two kinds: first, heating rate studies under conditions comparable to commercial processing in which the pressure was held at 1 atm. for each temperature tested; second, for academic interest, the temperature was held constant while the steam-air ratio of the atmosphere was varied for each test.

In the heating rate studies at 165, 180 and 195°F. and one atmosphere of pressure, the laboratory retort was used with the lid closed but not fastened. The temperatures of the steam-air mixture were measured using a thermocouple sensing element located at the mid-point-of-the-jar level.

Steam, entering through the cross in the bottom of the retort, discharged at right angles to the retort diameter at a 45° angle with the bottom. A steam-air mixture can be described as an atmosphere condition of 100 percent relative humidity, probably with some fogging. The heat capacity of the system is, therefore, small and temperature control difficult.

In the atmospheric pressure studies, the retort was equilibrated at the test temperature before the jars were placed inside. The jars were added quickly to minimize cooling of the retort; only 2 quart or 4 pint jars could be added without upsetting the system. The temperature regulation was poorer than for the water bath, water spray or saturated steam tests. The standard deviation of the temperature at any point was, in the worst case, about 2.1°F., and the point to point variation was sometimes as much as 3.0°F.

The studies, at different steam ratios but the same temperature, were made by using the vapor and air removal system described above, a pressure control system to maintain total pressure and a temperature control system to maintain the temperature. Pressures were measured with a mercury manometer, corrected to barometric pressure. These latter tests bridged the gap between the saturated steam studies and steam-air studies at one atmosphere of pressure.

ANALYSIS

During the tests, the temperature in the jars under study was recorded automatically every minute. After a test was completed, the

data from the chart was plotted on semi-logarithmic paper according to the method described by Ball and Olson (1), and the slope of the heating curve (f_h) and the lag factor (j) determined. The integrated lethality (Ball and Olson, (1)) of the heat process, calculated at the heating medium temperature (U_{RT}), was computed for some of the tests. For these calculations, a thermal death time curve slope (z) of 18°F. was assumed.

RESULTS

Comparison of Water Bath and Steam-Air at 165, 180, and 195° F

The data for heating pint and quart jars in a water bath and in a steam-air mixture at atmospheric pressure are presented in Tables 2

TABLE 2—Heating characteristics of water (mean values)

Heating medium...		Water bath			Water spray			100% steam			Steam-air		
Parameters.....		j	f_h	U_{RT}	j	f_h	U_{RT}	j	f_h	U_{RT}	j	f_h	U_{RT}
Pints	165°F.	1.21	11.2	2.77	1.46	10.0	2.99	....	....	....	1.36	22.0	0.22
	180°F.	1.22	11.2	2.20	1.42	9.6	2.83	....	....	....	1.50	17.5	0.23
	195°F.	1.30	10.0	2.27	1.22	9.5	2.80	....	....	....	1.64	13.2	0.55
Quarts	165°F.	1.42	15.0	6.63	1.57	13.3	7.51	1.39	12.9	8.54	1.35	29.2	0.96
	180°F.	1.45	14.4	5.79	1.58	12.2	7.63	1.41	12.5	8.01	1.46	23.0	1.42
	195°F.	1.59	12.9	6.13	1.40	11.8	7.65	1.46	11.9	7.65	1.45	17.4	2.87

and 3. The mean values of the three parameters f_h, j, and U_{RT} are presented for both water and bentonite. These data are the means of four replications. The U_{RT}'s for water were calculated for a process time of 15 and 25 minutes for pints and quart jars, respectively, and for process times of 60 and 80 minutes for pints and quarts of bentonite, respectively.

TABLE 3—Heating characteristics of bentonite (mean values)

Heating medium...		Water bath			Water spray			100% steam			Steam-air		
Parameters.....		j	f_h	U_{RT}	j	f_h	U_{RT}	j	f_h	U_{RT}	j	f_h	U_{RT}
Pints	165°F.	1.98	49.0	4.31	2.01	47.5	....	2.05	46	....	1.85	54.9	3.27
	180°F.	1.94	48.5	3.34	2.12	46.5	....	1.83	47.5	....	1.82	51.2	3.07
	195°F.	1.97	49.0	2.25	1.98	48.2	....	1.82	50.2	....	1.92	50.4	2.09
Quarts	165°F.	1.80	77.2	3.96	1 78	74.0	4.26	1 74	77.5	3.92	1.92	74.1	3.12
	180°F.	1.80	73.8	2.60	1.72	75.8	4.12	1.75	77.2	2.15	1.80	79.4	1.71
	195°F.	1.75	75.9	1.72	1.74	74.8	2.85	1.76	75.5	1.64	1.73	77.5	1.59

The $U_{RT's}$ were not analyzed because these values are not comparable since the closer the initial temperature is to retort temperature, the higher will be the final temperature at the end of a fixed time (provided j and f_h are not temperature dependent) and, therefore, the higher the U_{RT}. The principal value of U_{RT} comparisons is the fact that this integrated value is the only way to take account of the fact that nearly two-thirds of the bentonite (and about one-fourth of the water) curves were broken (changes of slope of about 12 minutes at about 10°F. below bath temperature for the bentonite). Although U_{RT} comparisons among temperatures cannot be made, comparisons at the same temperature can be made between jars and media.

In both convection and conduction heating products, the container material, wall thickness, and container geometry are contributing factors to the overall heat transfer characteristics. However, the contribution of these factors to the overall heat transfer is quite different for a convection heating product inside the container, as compared with a conduction heating product. In conduction heating, the product itself provides the greatest resistance to heat transfer. Therefore, even quite large changes in wall thickness, for example, do not appreciably change the overall heat transfer coefficient; the heat transfer is product limited. In convection heating, the overall heat transfer is much more sensitive to wall material. (See Townsend, *et al.* (6), glass vs. tin).

Comparison of 100 Percent Steam and Steam-Air Mixtures

The obvious differences between water and steam-air mixtures at the same temperatures resulted in a more extensive study of the effect of air on the heating rate. A series of tests were conducted in which saturated steam was compared with 75 percent steam-air mixtures (ratio of partial pressures calculated on a perfect gas basis) at several temperatures over the range from 165°F. to 225°F. Table 4 presents the average (two to eight individual readings) heating rates and lag factors. The individual and mean f_h values are illustrated as a function of temperature for saturated steam in Fig. 1.

In Fig. 2, the average f_h values are illustrated as a function of temperature for both the 100 percent and 75 percent steam-air mixtures. Two important conclusions can be made: (1) there is a marked difference between the f_h for saturated steam and for steam-air mix-

TABLE 4—Average lag factor and heating rate of quart jars of water heated in 100 percent steam and a 75 percent steam-air mixture at several temperatures

Temperature °F.	j		f_h	
	75% Steam	100% Steam	75%	100%
165	1.29	1.39	15.6	12.9
180	1.44	1.41	13.9	12.5
195	1.41	1.46	13.0	11.9
210	1.41	1.36	12.4	11.8
225	1.34	1.46	12.5	11.2

tures at all temperatures, and (2) the heat transfer characteristics of steam are a function of temperature in the range studied since an increased rate of heating (smaller f_h) accompanied increases in temperature. Whether this change in f_h with temperature is analogous

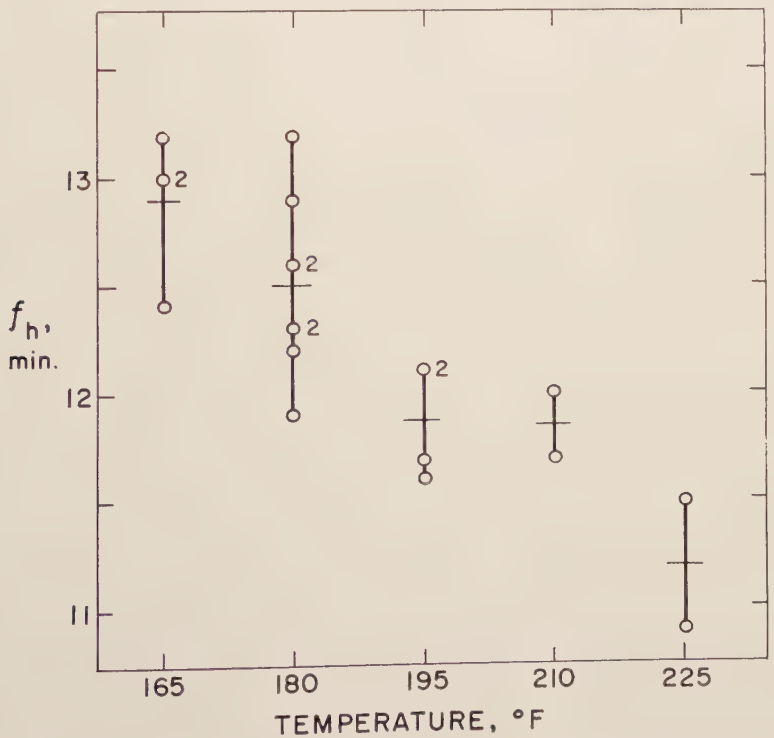

Fig. 1. Slope of the heating curve (f_h) of quart jars of water in saturated steam.

to the variation found by Evans (3) in his study and analysis of conduction heating, in which the decrease in f_h was shown to be a function of temperature according to changes in the thermal diffusivity, cannot be analytically demonstrated. The reason it can't is because there is at present no satisfactory derivation for the slope of the heating curve for convection heating products. One possible explanation may be that since these jars were at the same initial temperature, the larger temperature differentials accompanying the higher processing temperatures provided an opportunity for stronger convection currents.

Figure 3 illustrates the variation in the f_h value of water in steam-

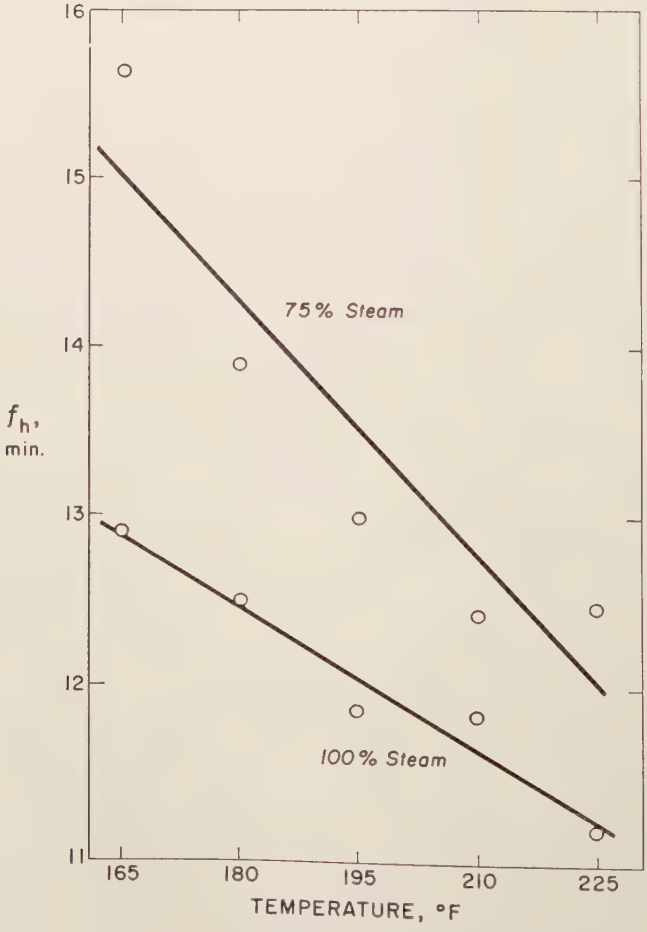

Fig. 2. Average heating rates of quart jars of water.

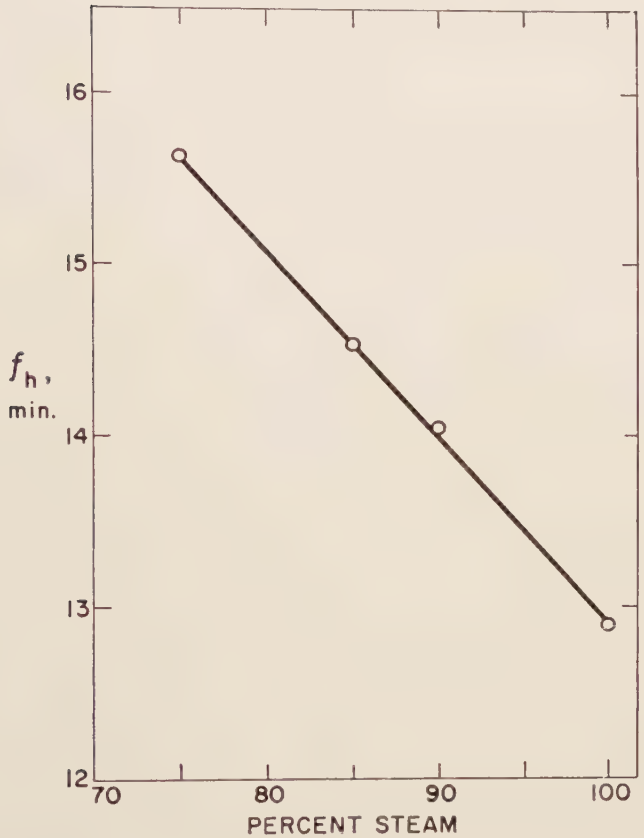

Fig. 3. Heating rate of water in quart jars in 165° F. steam-air mixtures.

air mixtures at 165°F. as a function of the percent of steam present. Each point (only 2 at 75 percent steam) is the average of four determinations.

From this evidence, it can be concluded that the increase in the rate of heating (decrease in f_h) of water, shown in Table 2, is composed of at least two parts—the decrease in f_h with increasing temperature, and the decrease in f_h as the percent of steam increases and approaches 100 percent.

The increase in f_h of jars of water in a steam-air mixture compared to jars of water in steam and the increase in f_h of jars of water with decreased percentages of steam appears to be due to a decrease in the heating medium heat transfer film coefficient that occurs when a vapor

condenses in the presence of a non-condensable gas. Kern (4) discusses heat transfer involving condensation of a vapor from a non-condensable gas, as it applies to process heat transfer, and notes that for the condensation of steam from steam-air mixtures in heat exchanges, it is often possible to have a variation in the overall heat transfer coefficient from 1500 B.t.u. (hr)(ft^2)(°F) at the inlet to a value of 15 at the outlet. The decrease in heat transfer rate parallels a decrease in the percentage of steam present which appears to be the same phenomenon that was observed in these experiments.

In general, variations in the lag factor follow the opposite trend of the slope of the heating curve; however, the systematic variation in lag factor, if it exists, is not as large as the variation in f_h, and the data do not in every case verify the conclusion that lag factor is an increasing function of temperature (See Tables 2 and 4). However, it is concluded that both j and f_h for convection heating are either dependent or functions of a common parameter, such that increasing f_h's can be associated with decreasing j's and vice versa.

Comparison of Water Spray With Saturated Steam

Pint and quart jars of both a 5 percent bentonite suspension and water were heated in a water spray at the three temperatures 165, 180, and 195°F. These data are also included in Tables 2 and 3.

Quart jars of bentonite at the three temperatures were compared by an analysis of variance to determine the heating efficiency of water spray vs. saturated steam. The analysis showed a significant difference in the f_h at the 1 percent level, water spray giving a smaller f_h than saturated steam (all temperatures considered together). The difference, although significant, is not appreciable, being 2 minutes for an f_h of about 75 minutes. Since a 5 percent bentonite solution heats primarily by conduction, the difference in the f_h between the heating media is perhaps attributable to the more favorable surface transfer coefficient of a water spray.

Comparisons of the individual and mean heating characteristics of water in pint and quart jars heated in a water spray are illustrated in Fig. 4. Analysis of variance of j and f_h for both pints and quarts reveals a significant difference in the heating rate at the different temperatures for quarts only. The trend for both heating curve parameters (f_h and j), in this particular instance, is a decrease with increasing temperature. The decrease in f_h is in line with the results of all the other experiments, but the decrease in lag factor (j) is not.

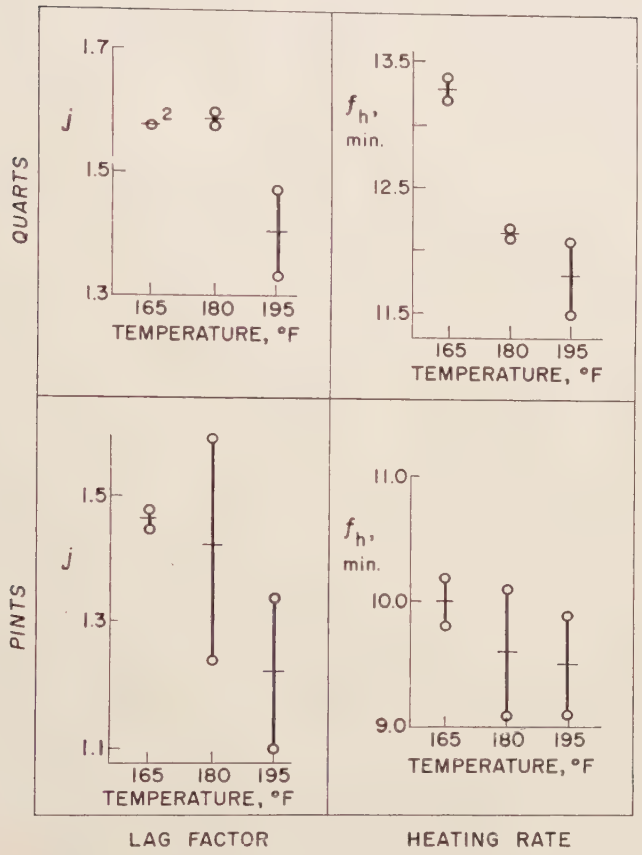

Fig. 4. Heating characteristics of water spray at various temperatures.

Discussion of All Heating Media

A comparison of the f_h of water in quart jars, as a function of temperature, for the four media, is given in Fig. 5. These data are taken from Tables 2 and 4 and Fig. 4. The dramatic change of f_h with temperature in the case of steam can be largely attributed to the change in steam-fraction with temperature. At 150°F., the steam fraction is less than 0.4, and at 180°F., it is about 0.5. These values should be compared with the heating rates in 75 percent steam at the corresponding temperatures (See Fig. 2).

In general, only minor differences among media and at different temperatures are found for bentonite; however, there are striking differences to be found both among media and at different tempera-

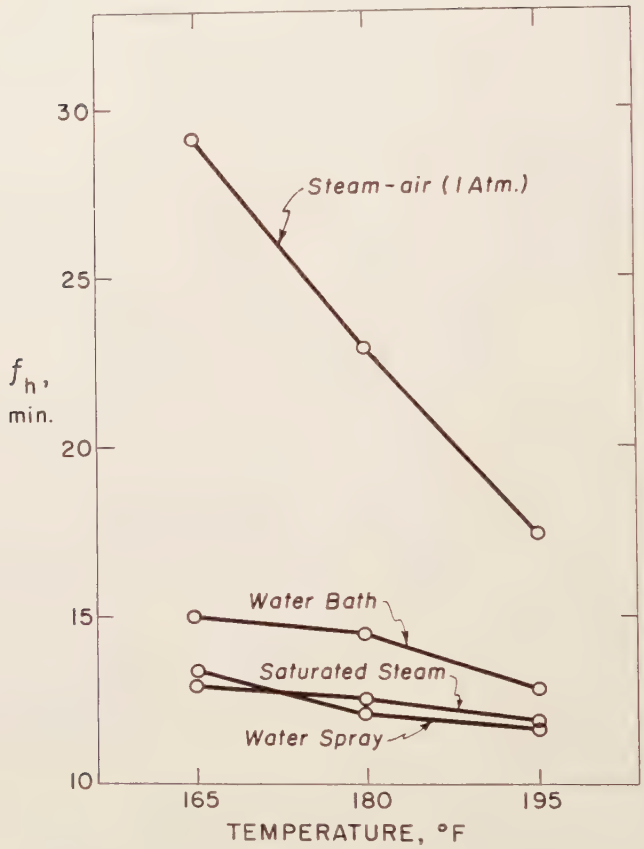

Fig. 5. Average heating rate of water in quart jars as a function of temperature.

tures in the case of convection heating. Presumably these differences in heating characteristics will also apply to liquids more viscous than water and to mixtures of solids and liquids. Some media differences at temperatures above the normal boiling point have already been exhibited.

Further research is indicated, particularly for water bath and water sprays, on the possible influence of spray intensity and agitation index on the heating rate, inasmuch as the rate of heating has been shown to be dependent on the heating medium.

These data should be helpful in explaining any difficulties that have been experienced by processors who converted from water baths to steam-air pasteurizers. If equal process times and temperatures were maintained using the two types of heating medium, then the lower

heating rate of convection heating food products in steam-air, at the same temperature, will have delivered correspondingly reduced sterilizing or pasteurizing values, particularly if the temperature is very far removed from 212°F.

SUMMARY

The heating rate (f_h), lag factor (j), and in some cases the integrated sterilizing value U_{RT}, have been evaluated for convection and conduction type of product (water and 5 percent bentonite) for pint and quart glass jars for four heating media. The heating media used were: agitated water bath, water spray, saturated steam, and steam-air mixtures. The results indicate:

1. Steam-air mixtures are less efficient than water bath, water spray, or saturated steam.
2. That steam-air mixtures vary in their efficiency according to the percent of steam present, increasing with increased percentages of steam.
3. The slope of the heating curve (f_h) decreases with increases in temperature over the range studied.
4. That a processor in converting from one heating medium to another, especially if going to a steam-air mixture, must either increase the process time or temperature to obtain the same lethality.

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PRODUCTION AND SIZE OF ROBINSON STRAWBERRIES AS INFLUENCED BY PLANT SPACING, RUNNER SPACING, IRRIGATION AND FERTILIZER

By HARRY K. BELL and JOHN D. DOWNES

DEPARTMENT OF HORTICULTURE

REPORTS ARE AVAILABLE regarding the effects of plant and runner spacing on fruit size and yield of strawberries (1, 2, 4, 5, 9); however, the Robinson variety has not been included. As the Robinson accounts for over half of Michigan's strawberry production (7) and the use of irrigation is becoming increasingly important, a study was initiated to determine the interactions of (1) plant spacing, (2) irrigation, and (3) fertilizer rates on fruit size and yield. This study was deemed important as Moulton *et al.* (11) found that Robinson under Michigan conditions made 16 plants per square foot of row while other workers, studying other varieties, found that less than half this number of runner plants produced optimum yields (1, 4, 5, 9, 14).

METHODS AND MATERIALS

Michigan certified virus-free plants were set on April 3, 1958 in rows 20 feet long and 3½ feet apart at the Michigan State University Sodus Experimental Farms. The experiment was set up as a factorial in split plot design with the nine main plots receiving three levels of irrigation and three fertilizers in factorial combinations of three plant spacings and three runner plant spacings.

The three irrigation treatments were no irrigation, irrigated when soil moisture dropped to 25 percent of field capacity and irrigated when soil moisture dropped to 50 percent of field capacity. Whenever the moisture fell to the designated levels, the plots were irrigated to field capacity using perforated aluminum pipe sprinklers.

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Times for irrigation were determined by Bouyoucos gypsum blocks buried in rows at a depth of 6 inches and moisture readings were made with a Bouyoucos meter at 1- to 7-day intervals, depending upon the rainfall.

Fertilizer treatments consisted of these analyses: 12-12-12, 12-12-6, and 12-6-12. Applications were made as side dressings on April 21, May 13 and June 12 to give a total of 750 pounds per acre. The plots were cultivated and hand hoed after each application to work the fertilizer into the soil.

The three spacing of mother plants used were 12, 18, and 24 inches. Runner plant spacings included none, six inches, and 12 inches apart.

Runner plants were spaced by hand and were kept within 6- to 8-inch limits on either side of the mother plants to provide rows no wider than 16 inches. Those runners extending beyond these limits were removed at weekly intervals.

Fruit was harvested in 1959 every 2 or 3 days beginning on June 1 for a total of nine pickings. Yields were recorded in ounces and fruit size was determined at four peak pickings by counting the number of berries needed to fill a quart box.

Analysis of variance was used in the data reduction, including partitioning of variances into components (3, 6).

RESULTS AND DISCUSSION

Effects of Plant and Runner Spacing

Varying the spacing between plants at the time the field was set had no effect on yields. Spacing of runner plants 6 or 12 inches apart resulted in greater yields than where runner plants were not spaced (Table 1). The difference between yields resulting from 6- and 12-inch runner plant spacings was not significant.

Spacing at planting time had no effect on berry size but spacing runner plants 6 and 12 inches apart had a highly significant effect on berry size. The berries averaged 19.7 percent fewer per quart when runner plants were spaced 6 inches apart, and 14.8 percent fewer per quart when the runner plants were spaced 12 inches, than when the runner plants were not spaced.

Of interest was the finding that the size of the berries from the 12-inch spacing of runner plants was smaller than those from the 6-inch spacing. This difference was consistent throughout the ex-

TABLE 1—Influence of runner plant spacing of the Robinson strawberry on yields and size of berry

Runner plants spacing	Yields (lbs./acre)	Size (berries/qt.)
Not spaced	8,606[a]*	67.3[a]*
6 inches	10,644[b]	54.0[c]
12 inches	10,733[b]	57.3[b]

* Means not followed by the same letter are different at the 5 percent level of probability in yield and at the 1 percent level of probability in berry size.

periment and was highly significant. An explanation for this could be the numerous small secondary crowns produced by the plants in the 12-inch spacing which developed late in the season and produced small berries.

While labor costs may not permit economic hand spacing of runner plants and removing surplus plants, these data indicate that gains in yield and berry size are possible through plant population control. However, a plant spacing of 24 inches in the new planting instead of 18 inches or even 12 inches did not reduce competition between runner plants sufficiently to make any material difference in yields or berry size in this study, regardless of the rates of irrigation and fertilization used.

Neither irrigation, fertilizer, nor spacing of mother plants altered the effect of runner plant spacing on yields in this study. The consistency of the runner plant spacing effect and the failure of the other variables to significantly influence this effect indicates the general applicability of this cultural practice for increasing yields and size of berries. Thus, spacing the initial plants up to 24-inches apart may be employed with the heavy runner plant-producing Robinson variety without reducing yields. A knowledge of these trends will be useful, for it is evident that wide plant spacing will be needed for mechanical harvesting of strawberries.

Effects of Irrigation and Fertilizer

Irrigating to maintain soil moisture above 25 or 50 percent of field capacity during the year of planting (1958) had no significant influence on yields of Robinson variety the following season (1959). However, applying water when the moisture level dropped to 50 percent of field capacity decreased average berry size (Table 2)

probably by promoting growth and development of small secondary crowns which in turn resulted in reduced berry size the following year (1959). The single irrigation required to maintain available moisture above the 25 percent level had no different effect on berry size than no irrigation.

The rainfall pattern in 1958 was favorable for early development of runners. Soil moisture was not limiting until July because 4.4 inches of rain fell in June during the period of development and establishment of the early runners plants. Plants established in June are considered the most productive the following fruiting season (10, 12, 13). The 4.4 inches of rain in June, 1958, the year of planting, may account for no responses in yield the following year.

Varying the phosphorous or potassium content of fertilizer treatments had no effect on yield in this experiment. Loree (8) reported similar results with the Dunlap variety. The partitioning of variance for fertilizers into its components suggested that the level of potash supplied the year of plant production might have been related to size of berry (F_{05}=5.32, F=5.05 at d:f. 1:8). The average number of berries per quart for the 84 pounds per acre rate of K_20 (750 lbs. of 12-12-12 or 12-6-12) was 57.0 compared to 60.8 for the 42 pounds of K_2O rate (750 lbs. of 12-12-6), a difference of only 3.8 berries per quart.

TABLE 2—The value of supplemental irrigation on berry size of the Robinson strawberry

Level of available moisture before irrigation(*a*)	Average number of berries/qt.(*b*)
Average of no irrigation and 25% of field capacity	58.2
50% of field capacity	62.2

(*a*) To bring moisture to field capacity in top 12 inches of soil.
(*b*) Means significantly different at the 1 percent level of probability.

SUMMARY

1. A study was designed to evaluate the interaction of spacings of Robinson strawberry plants on yield and berry size at planting time and runner plants in the matted row with variable irrigation and fertilizer treatments.

2. Spacing mother plants at time of planting 12, 18, and 24-inches in the row had no effect on yield or berry size.

3. Spacing of runner plants at 6 and 12 inches resulted in larger yields and berry size than when the runner plants were not spaced. The berries were smaller from plots with runner plant spacing of 12 inches than from plots where runner plants were spaced at 6 inches.

4. Varying the phosphorus or potassium content of the fertilizer treatments had no effect on yields or berry size.

5. The use of irrigation had no effect on yields, but it did result in smaller berries in the plants on plots allowed to reach 50 percent of field capacity before supplemental water was added.

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SOME CULTURAL STUDIES WITH ROBINSON STRAWBERRY IN MICHIGAN

By HARRY K. BELL and JOHN D. DOWNES

DEPARTMENT OF HORTICULTURE

SINCE ITS ORIGIN in Michigan in 1934 (4), the Robinson variety of strawberry has increased in importance to a point where it now makes up over half the state's production (1, 5). Although varieties have been shown to differ markedly in their response to various cultural practices (2, 3, 7), reports devoted to the Robinson variety are lacking. Accordingly, a study was initiated to determine the value of (1) starter solution used at the time of planting; (2) dormant cold storage plants versus freshly dug plants; and (3) side dressing in the spring of the fruiting year with various types of nitrogen (N) carrying fertilizers. The findings of several years observations are reported herein.

MATERIALS AND METHODS

All studies were conducted on Kalamazoo sandy loam soil grading into Oshtemo loamy sand at the Sodus Horticultural Experiment Station near Sodus. Michigan certified virus-free Robinson plants[1] were used throughout in this work. All plots were composed of single rows 3½ feet apart with plants spaced 2 feet in the row. A randomized design with four replications was employed for each study.

Use of Starter Solutions

In 1955, freshly dug Robinson strawberry plants were set on May 16 in plots of 12 plants to compare the use of water alone with 10-50-10 fertilizer starter at 3 pounds to 50 gallons of solution. One-half pint of water or starter solution was used per plant at time of setting.

[1] The cooperation of Mr. Robert Buskirk, Paw Paw, Michigan and Mr. Charles Zollar, Benton Harbor, Michigan in supplying these plants is hereby gratefully acknowledged.

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In 1956, the program of plots and treatments of 1955 was repeated with a planting date of April 26, but with the addition of another starter fertilizer treatment, 10-52-17 at 3 pounds to 50 gallons.

Observations included survival of plants and yield of berries.

Use of Dormant Cold Storage Plants

Twenty plants were set in each plot in the field on May 1, 1957 to compare freshly dug plants with dormant cold storage plants dug in April of the same year and held at 28-30° F. until planting.

Spring Fertilizer Applications

Single row plots of 25 feet were fertilized at the time of full bloom on May 14, 1958 as follows: (a) Urea, to supply 15 and 30 pounds of N per acre; (b) ammonium nitrate, to supply 15 and 30 pounds of N per acre; and (c) 12-12-12 to supply 15 and 30 pounds of N per acre; and (d) no fertilizer. The materials were sidedressed by hand and irrigated into the soil with ½-inch of water. Yields were recorded for each of nine harvests, and berry counts (number of fruits per quart) taken at the four peak harvests. When making the berry counts, the number of cull berries were also recorded.

RESULTS AND DISCUSSION

Use of Starter Solutions

Survival among plants set in 1955 with the use of water averaged 94 percent (11.25 $\pm$ 0.96 plants per plot) as compared to 8.3 percent (1.00 $\pm$ 0.71 plants) for those receiving 10-50-10 starter solution. Mortality among the plants treated with starter solution obviated the need for yield comparisons. Similar results were obtained by Parker in Virginia with a sodium nitrate solution on the Pocahontas variety (6).

In 1956, when there was no plant mortality, starter fertilizer applications gave no increase in growth or yields, as reported by Reath (7). The average for all treatments was equivalent to 12,433 ($s = 2{,}880$)[2] pounds per acre.

Lack of response to the added fertility may be explained by the relatively high levels of stored nutrients normally found in roots and crowns of the strawberry plant (8).

[2] Standard deviation.

As a consequence of these studies and numerous field observations, the use of soluble high analysis fertilizer starter solutions at planting time cannot be recommended generally for the Robinson strawberry on the light textured soils of southern Michigan.

Use of Dormant Cold Storage Plants

An increasing number of Michigan plant nurseries are finding it necessary to hold strawberry plants in cold storage. The performance of these plants compared to freshly dug plants is important to both growers and nurserymen. No difference in growth or development was noted in 1957 or 1958, and no significant difference in yields was obtained in 1958. The average per acre equivalent yield was 15,115 ± 1668 pounds.

The results obtained in these experiments with Robinson agree with those reported from other areas for other varieties (2, 3, 10). Robinson plants dug when dormant and stored at 28-30°F. yielded as well as freshly dug plants. As pointed out by Bringhurst and Voth (2) and emphasized by Guttridge (3), however, varieties differ in the temperatures required for maintenance of dormancy in storage, and success in the use of cold storage plants is heavily dependent upon dormancy at digging, proper handling in storage, and early planting. Cold storage offers a means of annual summer planting and single cropping in adapted areas (2, 3, 10).

Spring Fertilizer Applications

Applications of fertilizer in the spring of the first year of production is a common practice in Michigan, but research has shown that if high fertility and good cultural practices are maintained in the planting year, applications of nitrogenous fertilizer during spring of the fruiting year are unnecessary with Premier (9). The results obtained with Robinson in the experiments herein reported showed neither benefit nor detriment from the spring fertilizer applications. Yields averaged 15,098 pounds per acre; average size of berry was 48 per quart; and culls averaged 2.1 berries per pound. Extra nitrogen in the spring of the fruiting year may contribute to soft berries (9).

There was no trend of response to the three rates of nitrogen employed, no differences among carriers, and no response to phosphorus and potash in the presence or absence of added nitrogen. These findings do not imply that benefits from spring fertilizer applications

may not be expected where fertility levels are inadequate during the year of planting, or where extensive leaching results from heavy rains or continued irrigation for frost protection.

SUMMARY

Soluble fertilizer starter solutions applied in mid-May at planting time on Robinson strawberries drastically reduced plant survival in a hot, dry year, when compared to the use of water, and provided no benefits in yield when planted in late April of a more normal season.

Robinson plants dug when dormant and stored at 28-30° F. were fully equal to freshly dug plants in terms of yield.

Applications of urea, ammonium nitrate or 12-12-12 fertilizer at rates supplying 15 and 30 pounds of actual N per acre in the spring had no effect on yields or quality of Robinson strawberries which were adequately fertilized the year of planting. These treatments did not differ from each other or from the check in terms of yield, quality, or change in berry size over the harvest season.

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SOME PRODUCTION AND MARKETING TRENDS FOR MICHIGAN APPLES WITH SPECIAL ATTENTION TO THE JONATHAN VARIETY

By G. N. MOTTS

Department of Agricultural Economics

During the past year or two, an increasing number of Michigan apple growers, shippers, and receivers have been considering possible advantages in concentrating much of the total sales promotion efforts given to Michigan apples in general upon one or a limited number of varieties. Since the Jonathan variety leads the "Big 4" in Michigan (Jonathan, McIntosh, Northern Spy and Delicious), the information presented here may be a useful contribution to the development of an apple marketing program centered on Michigan Jonathan apples.

Status of Jonathan Variety

Although Jonathan accounted for only 5.7 to 7.6 percent of the total U.S. commercial apple crop from 1942 through 1959, they constituted from 16.6 to 28.9 percent of the Michigan production for that period (Fig. 1). The proportion of Jonathans in the total crop has been increasing more rapidly in Michigan than in the United States as a whole. The "Big 4" varieties have accounted for an increasing proportion of the total state crop, rising from 57 percent in 1942 to 72 percent in 1958 and 1959 (Fig. 2).

Another measure of the relative importance of these varieties is the number of bearing trees, for the post-war period, as shown in Table 1 and Fig. 2.

Comparative Yields

Yields per tree, over a period of years, is an important factor in the profitability and popularity of a variety with growers. However, win-

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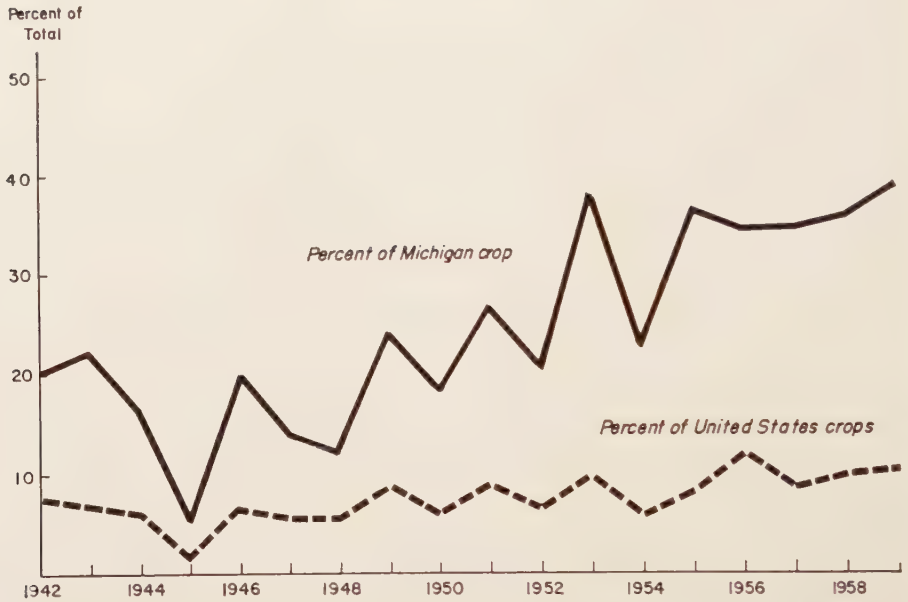

Fig. 1. Jonathan variety as a percent of commercial apple production in the U. S. and Michigan, 1942-59.

ter hardiness, market demand and other factors may be more important in total effect. State-wide data, apparently, are only available for the 1946-49 seasons, but are presented in Table 2 for the "Big 4" varieties. Jonathan yields per tree averaged lower than the all-variety average in three of the 4 years, as shown in Table 2.

Crop Disposition

Close to two-thirds of the commercial apple crop in Michigan has been sold on the fresh market in the post-war period, as shown in Table 3. The Delicious variety moves almost entirely to the fresh market, Jonathan and McIntosh are mostly sold on the fresh market, but some are processed. Small Jonathans have been processed in increasing volume as spiced apples. Northern Spy apples move to both fresh and processor outlets, with a growing percentage going to processors.

Storage Holdings

The capacity of storage facilities available for apples in Michigan exceeds 5 million bushels, including common or non-refrigerated fa-

TABLE 1—Number of bearing apple trees of major varieties in commercial producing counties of Michigan (a)

Year	All varieties (000)	Jonathan		McIntosh		Northern Spy		Delicious	
		(000)	Percent total	(000)	Percent total	(000)	Percent total	(000)	Percent total
1944	.....	...	21.0	...	10.8	...	10.6	...	11.3
1945	2,860	Not tabulated							
1946	2,410	613	21.8	346	12.3	264	9.4	340	12.1
1947	2,720	574	21.1	302	11.1	283	10.4	400	14.7
1948	2,600	536	20.6	382	14.7	354	13.6	286	11.0
1949	2,400	324	22.6	322	13.4	274	11.4	324	13.5
1950	2,430	578	23.8	318	13.1	294	12.1	367	15.1
1951	2,300	639	27.8	283	12.3	276	12.0	322	14.0
1952	2,340	569	24.3	356	16.2	381	12.0	311	13.3
1953	2,000	576	28.8	298	14.9	256	12.8	298	14.9
1954	1,970	463	23.8	469	13.9	272	13.8	226	11.5
1955	2,420	658	27.2	375	15.5	315	13.0	319	13.2
1956	2,420	694	28.7	392	16.2	230	9.5	339	14.0
1957	2,440	630	25.8	383	15.7	307	12.6	276	11.3
1958	2,470	627	25.4	380	15.4	286	11.6	430	17.4
1959	2,445	650	26.6	364	14.9	406	16.6	274	11.2

(a) 21 commercial counties, 1942-54; commercial counties 1955 data. There was very little change in the percentage of Jonathans when the reporting classification of commercial counties was changed.
Source: Michigan Agricultural Statistics, Michigan Crop Reporting Service.

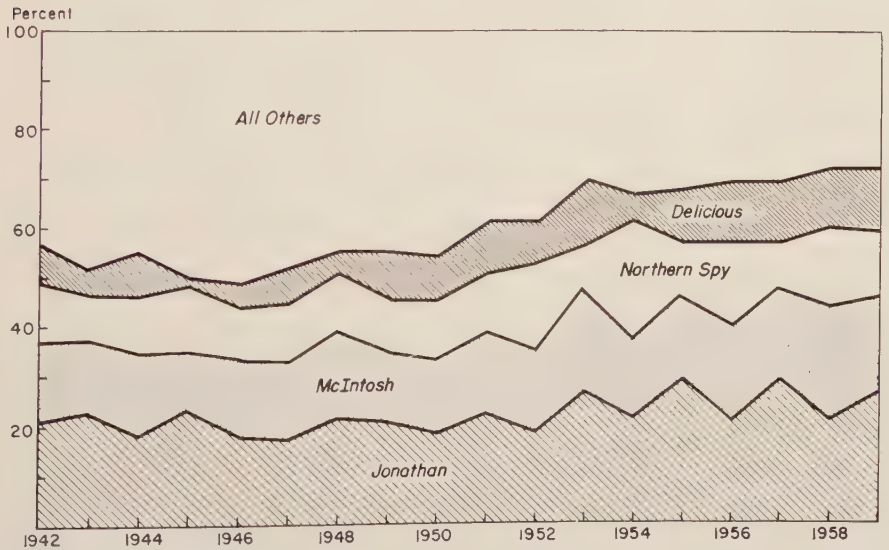

Fig. 2. Relative importance of the four leading apple varieties in Michigan, 1942-59.

TABLE 2—Average Michigan yields per tree, for leading apple varieties, 1946-49

(bushels)

Variety	1946	1947	1948	1949	Average
Jonathan.....	5.18	3.46	3.34	7.46	4.86
McIntosh.....	7.14	6.52	4.35	8.86	6.78
Northern Spy.....	6.73	6.02	4.96	7.80	6.38
Delicious.....	2.09	2.41	1.76	6.15	3.10
All varieties.....	5.01	4.40	3.92	7.59	5.23

Source: Michigan Apple Survey, 1950. Michigan Crop Reporting Service.

cilities, regular cold storage and controlled atmosphere storage. The capacity of controlled atmosphere storages in Michigan is now over 700,000 bushels. Approximately 40 percent of the large Michigan apple crops of the past 3 years can be stored at the orchards or shipping points.

The quantities of the four leading apple varieties in each type of storage facility in Michigan, as of November 1, 1959, is shown in Table 4. The four leading varieties normally account for close to three-fourths of the total quantity of Michigan apples in storage although they constitute about two-thirds of the state's commercial

TABLE 3—Production and disposition of Michigan apples, 1946-58 crops

(000 bushels)

Crop year	Production having value (*a*)	Farm disposition		Utilization of sales					
				Fresh sales		Processed			
		Home use	Sold	Sales	Percent of production	Canned	Frozen	Pressed	Other
1946....	7,560	325	7,235	4,360	58	980	400	1,495	(*b*)
1947....	6,400	325	5,820	3,960	64	330	200	1,330	(*b*)
1948....	4,830	200	4,630	3,565	74	275	35	735	(*b*)
1949....	9,388	300	9,088	5,818	62	630	261	2,345	34
1950....	7,320	280	7,040	4,340	59	730	270	1,570	130
1951....	8,000	280	7,720	5,620	70	500	150	1,280	170
1952....	6,200	240	5,960	4,380	71	610	210	680	80
1953....	9,200	240	8,960	6,130	67	975	275	1,370	210
1954....	6,600	180	6,420	3,850	58	760	440	1,250	120
1955....	8,300	220	8,080	5,300	64	660	260	1,680	180
1956....	12,000	280	11,720	7,820	65	900	700	1,990	310
1957....	10,000	250	9,750	6,800	68	950	440	1,416	144
1958....	12,000	240	11,960	7,540	63	1,350	500	2,450	120

(*a*) Commercial production minus quantities not harvested or excess cullage of harvested fruit.
(*b*) Jam and mincemeat included with "pressed".

Source: Michigan Agricultural Statistics. Michigan Crop Reporting Service.

apple production. Only about a fourth of the total crop of the lesser varieties are stored compared to 35 to 50 percent of the "Big 4" varieties.

During the 1955-59 period, from 32 to 44 percent of the Michigan commercial apple crops were in storage as of November 15, as shown in Table 5.

The development and rapid construction of controlled atmosphere storage facilities in Michigan is reflected in the longer marketing period shown in Table 5, compared to the situation as recently as

TABLE 4—Storage holdings of four leading varieties of Michigan apples on Nov. 15, 1959 in relation to the 1959 commercial crop

(thousand bushels)

Variety	Michigan crop	Stocks				
		Common	Cold	C.A.	Total	Percent of crop
Jonathan.....	3,150	24	821	276	1,121	36
McIntosh.....	2,300	12	702	282	996	43
Northern Spy....	1,630	168	614	26	808	50
Delicious(*a*).....	1,550	41	594	53	688	44
All others.....	3,320	101	742	9	852	25
Total.....	12,000	346	3,473	646	4,465	37

(*a*) Includes Red Delicious and regular Delicious.

Sources: Production —Table 2.
Stocks—Michigan State Apple Commission.

1955. Jonathan holdings on March 1, 1959 were about six times larger than on the same date in 1955 and there were still significant stocks on April 15, 1959.

The usefulness of the apple storage data, assembled and released by the Michigan State Apple Commission, is reflected in the smooth flow from storages to markets (Fig. 3).

The storage holdings of Jonathan apples in relation to total stocks of all varieties is shown in Table 6 for the United States for purposes of comparison with the situation in Michigan in Table 5. The outstanding importance of Michigan as a source of supply for Jonathan apples can be readily seen by comparing the Michigan and national holdings as of the first of each month for November through March in Tables 6 and 7 for the past five seasons.

TABLE 5—Storage holdings of four leading varieties of Michigan apples on November 15 for seasons 1955-59

Variety	1955		1956		1957		1958		1959	
	000 bu.	Percent of crop	000 bu.	Percent of crop	000 bu.	Percent of crop	000 bu.	Percent of crop	000 bu.	Percent of crop
Jonathan.....	630	26	642	27	915	32	1,204	46	1,121	36
McIntosh.....	600	42	874	37	559	30	1,223	45	996	43
Northern Spy....	450	51	1,201	60	560	60	1,027	52	808	50
Delicious(*a*).....	630	70	642	43	915	73	1,204	85	688	44
All others.....	380	14	923	25	760	25	677	20	852	25
Total.....	2,690	32	4,280	36	3,709	37	5,335	44	4,465	37

(*a*) Includes Red Delicious and regular Delicious.

Source: Production—Table 2.
Stocks—Michigan State Apple Commission.

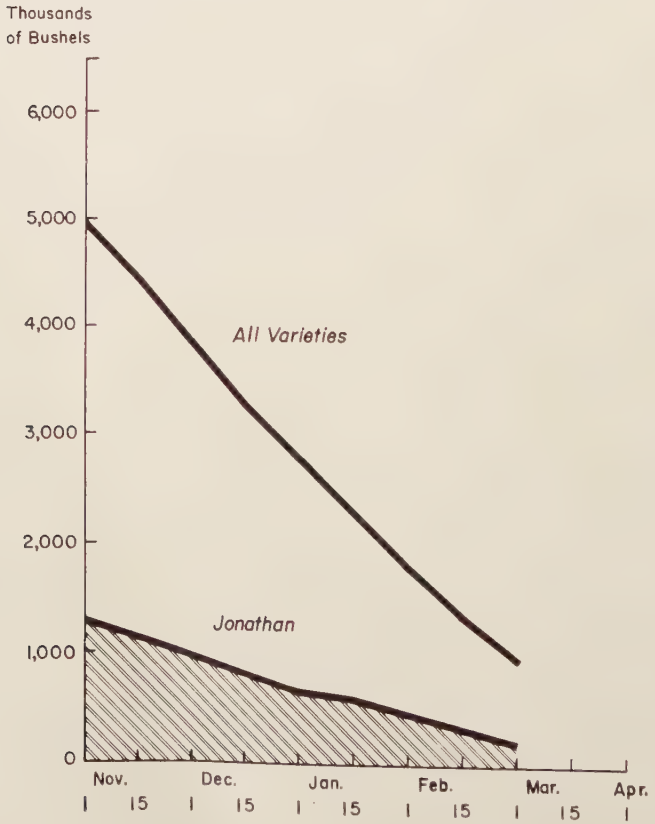

Fig. 3. Storage holdings of Jonathan and all apple varieties in Michigan, 1959-60 season.

TABLE 6—Storage holdings of Jonathan apples in Michigan compared to total stocks of all varieties, sem-monthly, seasons 1955-56 to 1959-60

(thousand bushels)

Date	1955-1956		1956-1957		1957-1958		1958-1959		1959-1960	
	Jonathan	Total	Jonathan	Total	Jonathan	Total	Jonathan	Total	Jonathan	Total
Nov. 1...	855	3,100	946	5,050	1,212	4,293	1,354	5,751	1,296	4,962
Nov. 15...	630	2,690	642	4,282	915	3,709	1,204	5,335	1,121	4,465
Dec. 1...	485	2,230	525	3,616	862	3,307	1,041	4,754	970	3,855
Dec. 15...	445	1,880	424	3,213	597	2,718	887	4,339	813	3,279
Jan. 1...	335	1,585	362	2,820	461	2,259	642	3,700	668	2,808
Jan. 15...	295	1,279	262	2,252	336	1,789	537	3,055	551	2,289
Feb. 1...	160	925	110	1,645	183	1,219	423	2,482	423	1,808
Feb. 15	60	655	57	1,117	120	873	301	1,956	312	1,360
Mar. 1...	35	255	25	815	88	726	226	1,380	180	994
Mar. 15...	...	.....	...	.....	...	.....	215	1,278	...	.....
Apr. 1...	...	.....	...	.....	...	.....	166	476	...	.....
Apr. 15...	...	.....	...	.....	...	.....	...	.....	...	.....

Source: Michigan State Apple Commission.

Seasonal Price Trends

The prices paid to growers for "most" sales of No. 1 quality Jonathan, McIntosh, Northern Spy and Delicious apples at the Detroit Eastern Wholesale Farmers Market on the 1st and 15th of each month from September through May for the past 10 years are shown in Table 8. While prices are characteristically higher at the start of the season for each variety, there were relatively few instances of an upturn in prices during the closing weeks each season on this market.

Since 5 to 10 percent of the commercial apple crop in Michigan normally moves across the Benton Harbor market, as shown in Table

TABLE 7—Storage holdings of Jonathan apples in the United States compared to total stocks of all varieties by months, seasons 1955-56 to 1959-60

fthousand bushels)

Date	1955-1956		1956-1957		1957-1958		1958-1959		1959-1960	
	Jonathan	Total	Jonathan	Total	Jonathan	Total	Jonathan	Total	Jonathan	Total
Nov. 1.....	1,025	51,352	1,162	45,123	1,487	59,008	1,442	58,312	1 469	53,959
Dec. 1.....	612	45,017	857	39,156	1,068	50,391	1,136	50,734	1,120	46,754
Jan. 1.....	347	35,489	408	30,064	597	39,037	668	39,547	767	34,972
Feb. 1.....	143	25,723	159	21,214	255	27,819	452	29,986		
Mar. 1.....	45	17,696	101	13,836	129	18,494	282	21,855		

Source: Michigan State Apple Commission.

TABLE 8—(Prices of four leading Michigan apple varieties, per bushel, at Detroit Eastern Wholesale Farmers Market, seasons 1950-51 to 1959-60. (Prices for "most" sales of No. 1 grade on 1st and 15th—or market dates of each month)

Variety and season	September		October		November		December		January		February		March		April		May	
	1	15	1	15	1	15	1	15	1	15	1	15	1	15	1	15	1	15
JONATHAN																		
1950-51	$....	$....	$....	$3.00	$2.75	$2.25	$2.50	$2.50	$2.50	$2.50	$2.50	$2.50	$2.25	$2.25	$2.25	$2.25	$2.25	$2.25
1951-52	....	....	2.00	1.75	1.50	1.50	1.50	1.50	2.00	2.00	2.00	2.00	2.00	2.00	2.25	2.25	....	....
1952-53	....	....	3.25	2.75	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	....
1953-54	....	3.25	2.75	2.75	2.50	2.50	2.75	2.75	2.75	2.75	3.00	2.25	2.25	2.25	2.25	2.75	....	....
1954-55	....	....	3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.00	3.00	3.00	3.00	....
1955-56	....	3.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	3.50	3.50
1956-57	....	....	2.75	2.75	2.75	2.75	2.75	2.50	2.50	2.50	2.50	2.75	2.75	2.75	2.75	2.75	....	....
1957-58	....	3.50	3.00	2.75	2.75	2.75	2.75	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	....	....
1958-59	....	3.50	3.00	2.25	2.00	2.00	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	....	....	....	....
1959-60	....	3.00	2.50	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	....	....	....	....
McINTOSH																		
1950-51	....	3.00	2.75	2.75	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
1951-52	2.75	2.00	1.50	1.50	1.50	1.75	1.75	2.25	2.25	2.25	2.25	2.25	2.25	2.75	3.00	3.00	3.00	....
1952-53	....	3.50	3.25	3.00	3.25	3.50	3.50	3.75	3.75	3.75	3.75	4.00	4.00	4.00	4.00	4.00	4.00	....
1953-54	3.25	3.25	2.75	2.75	2.25	2.75	2.75	2.75	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	....	....
1954-55	3.50	4.00	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	....
1955-56	3.50	3.50	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.25	2.25	2.25	2.75	3.25	3.25
1956-57	....	3.25	2.75	2.75	2.75	2.75	2.75	2.75	2 75	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	....
1957-58	3.75	3.25	2.75	2.75	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.25	3.00	3.00	3.25	3.25	3.25	....
1958-59	3.25	3.00	2.25	2.25	2.25	2.25	2.50	2.50	2.50	2.50	2.50	2.50	2.25	2.25	2.25	2.25	2.25	2.00
1959-60	3.25	2.75	2.25	2.25	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	....	....	....	....

TABLE 8—Concluded

Variety and season	September		October		November		December		January		February		March		April		May	
	1	15	1	15	1	15	1	15	1	15	1	15	1	15	1	15	1	15
NORTHERN SPY																		
1950-51	....	....	....	....	3.00	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75
1951-52	....	....	....	2.00	2.00	2.00	2.00	2.00	2.00	2.25	2.25	2.25	2.25	2.25	2.75	2.75	2.75	2.75
1952-53	....	....	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
1953-54	....	....	....	3.75	2.75	3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.25
1954-55	....	....	....	3.75	3.75	3.75	3.50	3.50	3.00	3.00	3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.50
1955-56	....	....	....	3.75	3.75	3.25	3.25	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.25	4.00	4.00
1956-57	....	....	....	3.25	2.75	2.75	2.75	2.75	2.75	2.75	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
1957-58	....	....	....	3.25	3.25	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.25	3.75	4.25
1958-59	....	....	....	3.00	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.25	2.25	2.00	2.25	2.00	2.00
1959-60	....	....	....	3.25	3.00	2.75	2.75	2.75	2.75	2.50	2.50	2.50	2.75	2.75	....	....	....	....
DELICIOUS																		
1950-51	....	....	3.50	3.50	3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.25
1951-52	....	3.00	2.75	2.75	2.75	2.75	2.75	2.75	3.25	3.25	3.25	3.25	3.25	4.00	4.50	4.50	4.50	4.50
1952-53	....	....	3.50	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25	5.00	5.00	5.00	5.00	5.00
1953-54	....	....	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75
1954-55	....	....	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25	....
1955-56	....	....	4.75	4.25	4.25	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75	4.25	4.25
1956-57	....	3.50	3.50	3.75	3.75	3.75	3.75	3.75	4.25	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	....
1957-58	....	5.00	4.00	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75	4.00	3.75	3.75	3.75	3.75	3.75
1958-59	....	....	3.75	3.50	2.75	3.00	3.25	3.25	3.50	3.50	3.50	3.50	3.25	3.00	2.50	2.75	3.00	3.00
1959-60	....	3.75	3.75	3.50	3.50	3.50	3.75	3.25	3.25	3.75	3.75	3.75	3.75	3.75	....	....	....	....

9, the average season prices for three of the leading varieties are included in Table 9. The Benton Harbor market closes in November, so there are rarely any appreciable sales of the Northern Spy variety.

TABLE 9—Average prices per bushel for major varieties of apples sold on the Benton Harbor market during the market seasons, 1942-58

Year	Jonathan			McIntosh			Red Delicious			All Varieties		
	000 bu.	Percent Michigan Jonathan	Price	000 bu.	Percent Michigan Mc.I.	Price	000 bu.	Percent Michigan R. Del.	Price	000 bu.	Percent Michigan Comm. crop	Price
1942.....	Not Available			Not Available			Not Available			808	9	1.28
1943.....										556	9	2.55
1944.....										604	8	2.42
1945.....										17	1	3.70
1946.....										791	10	2.06
1947.....										270	4	1.74
1948.....	119	15	2.56	86	10	2.20	28	16	3.40	852	18	2.27
1949.....	214	8	1.12	96	6	1 04	66	6	1.58	675	6	1.17
1950.....	178	13	1.92	93	8	1.78	115	17	2.68	693	9	1.97
1951.....	180	8	1.31	95	6	1.47	94	9	2.03	625	6	1.55
1952.....	66	6	2.65	34	3	2.52	57	10	3.62	376	6	2.74
1953.....	215	9	2.48	68	4	2.30	91	7	3.28	676	7	2.55
1954.....	121	9	2.56	39	4	2.87	49	12	3.75	402	6	2.86
1955.....	194	8	2.28	78	5	2.15	112	12	3.28	617	7	2.44
1956.....	232	10	2.18	84	4	2.05	133	9	3.40	710	6	2.26
1957.....	160	6	1.82	75	4	1.90	120	10	2.87	601	6	2.17
1958.....	182	6	1.80	83	3	1.84	98	6	2.43	626	5	1.88
1959.....	...	..	....	..	..	....	...	..	....	...	..	....

Source: Benton Harbor Market Summaries, 1942-58.

Market Territory

In recent years, Michigan apples have been shipped to markets in 25 to 30 or more states, as shown in Tables 10 and 11. Since Benton Harbor is the leading single point of origin for Michigan apple shipments, the quantities shipped from that point to markets in the United States and Canada are shown in Table 10. Practically all Michigan apples move to market by truck, so the carlot equivalents (650 bushels) of Michigan apples arriving by truck at 31 United States markets and three in Canada account for the reported unloads of Michigan apples on these markets during the 1951-58 period. Truck receipts were not compiled by the USDA for many of these markets until 1954 or 1956, as indicated in Table 11.

The market territory for Michigan apples reflects three basic factors: (1) the large population in Michigan and its four adjacent states absorbs over half the total fresh sales, (2) the location of other

major apple producing areas in New York, the Appalachian region, southern Illinois and northwestern Arkansas reduce the sales potentials in those directions, and (3) the transportation costs from Washington and other western states compared to rates from Michigan limits the Michigan market area on the west to a line running approximately from Bismark, North Dakota to Houston, Texas.

TABLE 10—Distribution of truck shipments of apples from Benton Harbor market, by states of destination, 1946-58

(000 bushels)

States	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958
Alabama	2	(a)	2	3	4	8	(a)	10	3	5	7	4	12
Arizona	..	..	..	..	..	..	..	1	2	2	..	..	..
Arkansas	1	(a)	..	(a)	2	10	4	7	4	8	28	15	14
Colorado	..	..	..	2	..	..	2	10	1	2	2	..	3
Connecticut	..	..	..	..	..	(a)	..	..	..	..	..	..	..
Delaware	(a)	..	..	..	..	1	2	2	..	..	..	..	..
Florida	..	(a)	(a)	4	4	3	4	6	(a)	1	4	6	4
Georgia	(a)	..	..	20	3	2	3	1	..	5	5	2	4
Illinois	62	70	95	59	56	42	32	30	67	54	102	90	104
Indiana	132	68	78	37	40	58	50	71	77	100	100	75	102
Iowa	264	16	74	111	175	96	40	76	73	49	123	45	56
Kansas	8	(a)	2	4	10	3	2	34	2	14	16	3	13
Kentucky	44	12	43	6	70	54	24	46	49	104	40	35	25
Louisiana	..	..	..	..	..	2	..	35	(a)	1	2	2	2
Maine	..	..	..	..	..	(a)	..	..	..	..	..	..	..
Maryland	..	..	..	..	..	..	1	2	..	..	..	..	..
Massachusetts	..	..	..	..	..	..	1	..	..	..	..	..	..
Michigan	39	24	30	36	20	18	43	43	27	33	52	52	45
Minnesota	13	2	3	..	10	2	6	2	9	2	8	22	15
Mississippi	(a)	..	(a)	(a)	(a)	9	5	1	(a)	4	1	2	5
Missouri	31	2	8	10	32	16	15	16	5	26	41	27	39
Montana	..	..	..	2	..	..	..	..	..	..	..	..	..
Nebraska	7	..	2	50	11	20	6	15	6	25	4	4	4
New Hampshire	..	..	..	..	..	(a)	..	..	..	..	..	..	..
New Jersey	..	..	..	..	..	..	..	10	..	..	8	4	3
New Mexico	..	..	..	..	..	..	..	(a)	(a)	..	..	..	(a)
New York	..	..	..	(a)	..	1	4	10	..	..	10	..	5
North Carolina	..	..	(a)	26	3	7	..	4	..	6	(a)	1	2

TABLE 10—Concluded

(000 bushels)

States	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958
North Dakota	(a)	..	..	7	..	..	1	5	15	10	8	8	6
Ohio	64	32	59	21	27	16	32	32	11	5	32	28	25
Oklahoma	6	(a)	3	11	8	7	21	35	4	19	20	17	4
Pennsylvania	(a)	..	..	..	..	7	5	15	..	..	..	(a)	..
South Carolina	..	..	(a)	2	..	..	2	4	..	..	..	..	..
South Dakota	(a)	..	3	1	..	7	3	5	15	10	..	1	..
Tennessee	8	4	12	63	42	47	41	42	11	60	27	49	30
Texas	(a)	..	(a)	..	2	15	1	3	(a)	(a)	3	1	3
Vermont	..	..	..	..	..	(a)	..	..	..	..	..	..	..
Virginia	..	(a)	..	(a)	5	4	1	4	(a)	1	3	2	4
West Virginia	6	21	23	101	5	20	13	83	8	35	22	45	40
Wisconsin	15	16	9	6	7	16	7	6	4	3	30	43	54
Canada	86	..	..	..	..	..	5	10	..	30	..	15	..
Total	791	270	447	582	536	491	376	676	401	617	710	601	626
Percent Michigan fresh sales	18	7	12	10	12	9	8	11	10	12	9	9	8
Total states	23	17	21	26	22	31	30	34	26	27	27	26	28

(a) Less than 1,000 bushels.

Sources: 1946-48 Annual Summary, Benton Harbor Market.
1949-51 Marketing Michigan Apples, U.S.D.A. Market News Service.
1952-58 Benton Harbor Market Summary, U.S.D.A. Market News Service.

TABLE 11—Truck unloads of Michigan apples at principal markets, 1951-58

(carlot equivalents)

Market	1951 (a)	1952 (a)	1953 (a)	1954	1955	1956	1957	1958
Atlanta	114	20	158	44	69	54	65	47
Birmingham	Not reported					15	38	36
Boston	..	..	..	..	1	7	2	..
Buffalo	Not reported					2	2	2
Chicago	1036	716	736	785	581	883	1071	1006
Cincinnati	Not reported			41	111	75	162	146
Cleveland	79	222	295	147	33	247	293	187
Columbia, S. C.	Not reported					..	..	3
Dallas	Not reported				9	23	17	21
Denver	Not reported			1	5	..	..	..
Detroit	677	505	554	659	720	648	836	864
Ft. Worth	Not reported				1	7	2	..
Houston	Not reported					2	7	13
Indianapolis	Not reported					78	101	202
Jackson, Miss.	Not reported				4	2	1	..
Kansas City, Mo.	19	61	160	83	52	119	67	139
Louisville	Not reported					128	274	296
Memphis	Not reported					..	78	77
Miami	Not reported					..	4	9
Milwaukee	Not reported					102	186	153
Minn.-St. Paul	Not reported					156	123	113
Nashville	Not reported					..	25	48
New Orleans	7	1	10	2	4	2	6	15
New York	..	..	..	1	1	..	..	..
Pittsburgh	1	13	69	4	1	24	42	33
Philadelphia	..	..	..	..	..	636	1	..
Providence	Not reported					..	2	..
St. Louis	125	170	284	252	310	294	310	353
San Antonio	Not reported					..	1	3
Washington, D. C.	..	..	..	1	..	56	..	..
Wichita, Kan.	Not reported					..	10	32
Total	750	740	715	2020	1900	1675	3725	3798
Montreal	..	..	..	..	..	4	..	..
Toronto	..	..	..	..	..	..	..	1
Winnipeg	..	..	..	..	..	..	41	58
Total						4	41	59

(a) May include some rail unloads.

Source: Marketing Michigan Apples. Market News Service, U.S.D.A.

JOURNAL ARTICLE ABSTRACTS

Effect of Inoculating the Chicken and the Turkey with a Strain of Trichomonas gallinarum

DELAPPE, IRVING PIERCE

Experimental Parasitology. 6(40): 412-417. 1957 (Journal Article 1555 from the Michigan Agricultural Experiment Station)

Trichomonas gallinarum was cultured in a modification of Laidlaw's medium from liver lesions of a turkey poult showing typical liver lesions of histomoniasis. *Histomonas meleagridis* was observed microscopically in smears made from these lesions, but they did not reproduce in culture. The trichomonads were subcultured at weekly intervals over a period in excess of 8 months.

Forty-five chicks were inoculated per orum with approximately 1,700,000 organisms. A similar number of uninoculated controls were maintained. Twenty turkey poults were inoculated per orum with approximately 1,600,000 organisms. A similar number of uninoculated controls were maintained.

Trichomonas gallinarum was never detected in the droppings of any control birds. Although on one or two occasions the organisms were also absent from the droppings of the infected birds, it was present at autopsy in smears of fecal contents.

There was no apparent loss of vigor in the infected birds nor was there any decrease in weight gains or feed consumption.

No deaths attributable to the presence of *T. gallinarum* occurred in either species.

Consumer Preferences for Chocolate Ice Cream

MEISER, J. A.

Proc. of the 52nd Annual Convention of the International Assoc. of Ice Cream Manufacturers Production and Laboratory Section. 2: 35-40. 1956. (Journal Article 1960 from the Michigan Agricultural Experiment Station)

An average of 22 percent of the consumers used in these experiments did not detect differences between high and low concentrations of cocoas or liquors when used in ice cream. Approximately 31 percent of the participants recognized no difference between ice cream flavored with liquor or cocoa.

Residents of Michigan exhibited a flavor preference distinctly different from that of non-Michigan residents. Michigan choices were for low concentrations of cocoa (2.5%) and liquor (3.75%). Only in the use of Dutch process cocoa was this preference statistically significant.

Both Michigan and non-Michigan residents exhibited a highly significant preference for natural process liquor as compared to natural process cocoa.

Ammonia Losses During and After Application

HANSEN, C. M.; L. S. ROBERTSON AND M. M. MORTLAND

Agr. Ammonia News, May-June 1957. (Journal Article 2063 from the Michigan Agricultural Experiment Station)

Farmers have been concerned with the losses of ammonia when nitrogen low pressure solutions containing free ammonia have been applied to the soil surface. This practice was never recommended by the manufacturers of the solutions. Data were obtained from an equivalent amount of a solution containing free ammonia applied to the soil surface, and 2 inches below the soil surface. The rate of ammonia loss, when the material was applied to the surface, was greatest immediately after application. The rate of loss decreased with the passing of time. Losses were still evident after six hours. Losses of ammonia from the surface application and 2 inches below the surface amounted to 27 percent and were insignificant, respectively, of the total volatile ammonia in the solution. Losses were equal to 4 percent of the volatile ammonia after 6 hours.

Growth of Concord Grapes in Sand Cultures as Related to Various Levels of Essential Nutrient Elements

BERGMAN, E. L.; A. L. KENWORTHY; S. T. BASS AND E. J. BENNE

Proc. of the Amer. Soc. for Hort Sci. 75: 329-340. 1960. (Journal Article 2145-B from the Michigan Agricultural Experiment Station)

The effect of three levels of 11 essential nutrient elements on growth of Concord grape vines in relation with petiole and stem analyses was studied in the greenhouse. One-year-old rooted cuttings were grown for 16 weeks with nutrient solutions using quartz sand as growing media.

Petioles and stems of each plant were analyzed for N, P, K, Ca, Mg, Fe, Mn, B, Cu, Zn, and partially for chloride.

Total linear growth, total dry weight accumulation by the plant, as well as dry weight accumulation by each of the roots, stems, petioles, and leaf blades were taken.

Low levels of nutrient depressed dry weight accumulation in the following decreasing order: K, N, Ca, P, B, Mg, Zn, Mn, Mo. High levels depressed dry weight in the following decreasing order: K (Cl), Mg, $Ca(SO_4)$, Ca(Cl), N, P, $K(SO_4)$, Fe, B, Mn. The 5Mo treatment resulted in the greatest dry weight accumulation by the plant.

Linear growth was depressed by deficient levels of nutrients in the following decreasing order: N, K, P, Ca, B, Cu, Zn, Mo, Fe, Mn, Mg. High levels of nutrients were depressing in the following decreasing order: Mg, Ca, K(Cl), $Ca(SO_4)$, N, Fe, Mn, Mo, Zn, $K(SO_4)$, Cu, B. The check treatment resulted in the greatest linear growth with the 5P treatment close second.

Chronological appearance of visible deficiency or toxicity symptoms did not correlate with the depressive effects of the different elements on total linear growth and dry weight accumulation. Deficiency symptoms appeared in the following order: -N after 4 weeks, 5N and 5P after 6 weeks, -K and $5K(SO_4)$ after 9 weeks, 5K(Cl) and -Fe after 10 weeks, -Mg, -Mn, -B, and -Cu after 11 weeks, -P, -Ca, -Zn after 12 weeks, and -Mo after 14 weeks.

It was impossible to grow plants with N for longer than 3 weeks. Mg deficiency symptoms appeared more quickly on plants with high K treatments than on those treated with Mg deficient solutions.

Visible deficiency symptoms on plants, as described, were associated with the following nutrient levels in the petioles: N-.51 percent, P-.10 percent, K-.47 percent, Ca-.26 percent, Mg-.14 percent, Mn-18p.p.m., B-14p.p.m., Cu-28p.p.m., and Zn-11p.p.m.

Occurrence and Control of Magnesium-Deficiency Symptoms in Some Common Varieties of Celery

Johnson, D. E. E.; J. F. Davis and E. J. Benne

Soil Sci. 91(3): 203-207. 1961. (Journal Article 2157 from the Michigan Agricultural Experiment Station)

A 2-year study was conducted in an effort to determine the basic nutritional causes of magnesium deficiency in certain varieties of green celery grown on organic soils in Michigan. Plants grown at four different locations received varying amounts of magnesium sulfate, applied either to the soil or directly to the plants in foliar sprays. The foliar sprays were more effective than the soil treatments in controlling the deficiency symptoms Both plants and soils were analyzed to determine what relationships existed or were introduced in the plants by the treatments. Higher magnesium contents were in most cases accompanied by lower amounts of calcium and potassium than found in plants with lower magnesium contents. Crop composition was found to vary with changes in its root environment, its above ground environment, and its stage of maturity upon harvesting. Accompanying these changes in different years, the minimum magnesium content at which the control of deficiency occurs also varies.

Fast and Easy Job-Study Improves Labor Efficiency

Keppeler, R. A.; C. W. Hall and P. J. Thorson

Food Engr. 33: 50-53. 1961. (Journal Article 2244 from the Michigan Agricultural Experiment Station)

Time study can be accomplished by a variation of work sampling called "occurrence tabulation" at less cost and time than timed time study. Basic and standard times can be calculated from percent of occurrence of each element. The occurrences are the result of observations at random times of each member of the operating crew. After 3 or 4 hours of study the number of observations needed for each element to make the study statistically significant are calculated. The study is continued until the calculated number is reached for each element.

The basic times are calculated from this percentage of total units produced during the study and the elapsed time of the study. Standard times for each element and for each operation are calculated from the basic times plus an allowance for necessary nonproductive time.

Isolation of Indole-3-Acetic Acid from Corn Kernels and Etiolated Corn Seedlings

Hamilton, R. H.; R. S. Bandurski and B. H. Grigsby

Plant Physiol. 36(3): 354-359. 1961. (Journal Article 2297 from the Michigan Agricultural Experiment Station)

Methods found useful in the isolation of IAA from kilogram quantities of plant tissue are described. A buffered ether-water partition column technique was

developed. The use of trace amounts of IAA-2-C^{14} was especially valuable during the isolation, and in evaluating the recovery. IAA was detected in 80 percent ethanol extracts of corn kernels and shoots, as well as vegetative sugar beet roots and leaves. The difficulties of detection of IAA in corn shoots are discussed in detail and it is suggested IAA may occur as a liable complex in ethanol extracts of this tissue. An 80 percent ethanol-soluble, aqueous-insoluble fraction from corn kernels was found to release IAA upon alkaline hydrolysis. It appears this fraction may be protein in nature.

Cracking and Rot Control of Sweet Cherry

CATION, DONALD AND JAMES FRIDAY

Plant Disease Reporter. 43(3): 394-395. 1959. (Journal Article 2372 from the Michigan Agricultural Experiment Station)

Twelve fungicidal chemical compounds or combinations of chemicals applied to Windsor sweet cherry resulted in differences of 12 to 96 percent in amount of cracked fruit. Other differences noted were in fruit size, maturity and rot control. A combination of low soluble copper, wettable sulfur and lime gave the least cracking, while highly surfactant materials appeared to give the most. Copper-sulfur-lime, ferbam-sulfur-glyodin, Acti-dione-glyodin, and sulfur-glyodin plots showed the least brown rot. Acti-dione dwarfed the fruit and delayed maturity. The copper spray reduced fruit size and gave objectionable residue but was the most profitable application for the processing market.

Biological Evaluation of Gibberellins A_1, A_2, A_3, and A_4 and Some of Their Derivatives

BUKOVAC, M. J. AND S. H. WITTWER

Plant Growth Regulation: 505-520. 1961. (Journal Article Number 2445 from the Michigan Agricultural Experiment Station)

Gibberellins A_1, A_2, A_3 and A_4, the n-alkyl esters of A_3, and some derivatives of A_1, A_3 and A_4 were bio-assayed utilizing several test systems with intact plants. In promotion of vegetative extension-bean epicotyl and celery petiole elongation-A_3 was most active followed by A_1, A_4 and A_2. Reduced epicotyl elongation following leaf blade applications of A_2 and A_4, as compared with A_1 or A_3, suggested limitations in the transport of A_2 and A_4 in the bean plant. A marked deviation from the usual order of growth extension activity among the four gibberellins occurred in stem elongation of the cucumber. Gibberellin A_4 was strikingly the most active followed by A_1, A_3 and A_2. Gibberellins A_3 and A_4 were more effective than A_2 or A_4 for accelerating flowering of both Great Lakes head and Grand Rapids leaf lettuce. Gibberellins A_1, A_3 and A_4 were more active than A_2 in promoting the growth of tomato ovaries at low dosages (3×10^{-4} or 3×10^{-5} M.), while growth was comparable with all four gibberellins at 3×10^{-3} M. All gibberellins stimulated germination of lettuce seed in the dark. Photo-induced dormancy of *Weigela* was partially overcome by treatment with gibberellins A_1 and A_3, whereas A_2 and A_4 were inactive.

Relationship of Molecular Structure to Biological Activity in the N-arylphthalamic Acids

Teubner, F. G.; S. H. Wittwer and J. Y. Shen

Plant Growth Regulation: 259-272. 1961. (Journal Article 2491 from the Michigan Agricultural Experiment Station)

The activities of several chloro- and methyl-derivatives of N-phenylphthalamic acid were evaluated with respect to tomato flower formation, parthenocarpic development of tomato ovaries, and straight growth of *Avena* sections. Modifications in molecular structure had almost identical effects on activity in all three biological responses. Both *ortho* and *meta* substitution of chloro- or methyl-groups enhanced the activity of N-phenylphthalamic acid, and the 2, 3- and 3,5-dichloro-, and the 2, 3, 5-trichloro-phenylphthalamic acids were the most active tested. In contrast, *para* and di-*ortho* substituents either abolished or had no effect on biological activity. While some of these substitutive effects suggested similarities to either the benzoic, phenylacetic or phenoxyacetic acids, others showed distinct differences. Continued study of this group of compounds should provide valuable information on the fundamental chemical structure requirements for plant growth-regulating activity of the molecular structure-biological activity relationships in the N-aryl-phthalamic acids.

Inhibition of Alcoholic Fermentation by Sorbic Acid

Azukas, J. J.; R. N. Costilow and H. L. Sadoff

Jour. of Bact. 81(2): 188-194. 1961. (Journal Article 2497 from the Michigan Agricultural Experiment Station)

Sorbic acid inhibition of alcoholic fermentation by intact cells of baker's yeast is dependent on the pH. However, inhibition of fermentative activity of cell free extracts prepared by blending in an Omnimixer with fine glass beads was not affected by pH. Therefore, it is believed that the pH effect observed with intact cells results from the greater permeability of the cell to the undissociated form of the acid. Using cell-free extracts, 5×10^{-3} M sorbic acid was shown to inhibit CO_2 production equally from glucose, fructose 1, 6-diphosphate and 3-phosphoglyceric acid. However, there was no evidence of any inhibition of aldolase, 3-phosphoglyceraldehyde dehydrogenase, phosphoglyceromutase, phosphopyruvic acid transphosphorylase, carboxylase, or alcohol dehydrogenase. Experiments with purified yeast enolase demonstrated that this enyzme was sensitive to very low levels of sorbic acid. The degree of inhibition was dependent on both the substrate and inhibitor concentrations but the type of inhibition appeared complex.

A Method of Studying Stresses Occurring in Plant Tissue during Freezing

Olien, Charles Robert

Crop Sci. 1: 26-28. 1961. (Journal Article 2570 from the Michigan Agricultural Experiment Station)

A new method based on electrophoretic principles makes possible the continual evaluation of changes in the liquid extracellular water content of any

region of a plant during freezing and thawing. By use of this method, the temperature at which ice formation is initiated and the type of stress occurring in the tissue can be evaluated. The method is being used to study winter cereals having various degrees of hardiness induced by controlling environmental conditions during plant development. The plants are tested during a gradual change in temperature which causes stress of the type that could occur naturally.

An Analysis of Production Practices of Sugar Beet Farmers in Michigan, 1958

DAVIS, J. F. AND M. G. FRAKES

Jour. of the Amer. Soc. of Sugar Beet Tech. XI(4): 313-319. 1961. (Journal Article 2579 from the Michigan Agricultural Experiment Station)

Production practice data from approximately 70 percent of the sugar beet acreage in Michigan in 1958 were obtained through the cooperative efforts of the Agronomic Research staff of the Michigan Sugar Company. The data were put on IBM cards and analyses made. A description of the methods used, the type of data compiled, and the type of analysis obtained were presented.

The Effect of Added Enzymes upon the Free Amino Groups and Organoleptic Ratings of Irradiated Beef During Storage

WEST, R. G.; A. M. PEARSON AND F. J. MCARDLE

Jour. of Food Sci. 26(1): 79-83. 1961. (Journal Article 2580 from the Michigan Agricultural Experiment Station)

The catheptic activity in irradiated beef was studied from the standpoint of flavor and chemical change. During 6 months' storage of raw irradiated beef, cooked beef with added active cathepetic enzymes and cooked beef to which an inactivated enzyme preparation was added, taste panel scores showed an inverse relationship with the amount of free amino nitrogen liberated. The raw meat and that with the added active enzyme preparation increased markedly in percentage of amino nitrogen during storage, whereas, the cooked meat to which the inactive enzyme preparation was added did not change greatly. Results indicate that the naturally occurring enzymes present in meat are the causative agents for the decline in acceptability during storage of raw irradiated meat.

The Effect of Physical Disturbance, Sound and Light on the Incidence of Blood Spots and Other Egg Quality Factors

STILES, P. G. AND L. E. DAWSON

Poultry Sci. XL(1): 189-195. 1961. (Journal Article 2615 from the Michigan Agricultural Experiment Station)

The separate influences of physical disturbance, sound and light variations on the incidence of blood spots and other egg quality characteristics were investigated. Shaking, frightening, and trapnesting birds had no significant effect on blood and meat spot incidence.

Eggs from birds in all pens, including the control, had an increased blood

spot incidence during the sound phase with eggs from birds submitted to a 24-hour-radio having the highest blood spot incidence. However, none of the sound treatments caused a substantial change in blood spot incidence or in other egg quality factors.

Eggs from birds receiving continuous light had a significantly higher blood spot incidence than eggs from birds receiving 14 hours of light per day. Eggs laid by birds given 15-minute intermittent light and darkness had a slight increase in blood spot incidence. Both continuous and intermittent light increased albumen height, egg weight, and Haugh score.

Swine Hematology from Birth to Maturity. I. Serum Proteins

Miller, E. R.; D. E. Ullrey; Inge Ackerman; D. A. Schmidt; J. A. Hoefer and R. W. Luecke

Jour. of Animal Sci. 20(1): 31-35. 1961. (Journal Article 2623 from the Michigan Agricultural Experiment Station)

Electrophoretic and total protein analyses were made on over 1,100 serum samples obtained from swine at frequent age intervals from birth to maturity. Rapid changes in total serum protein and electrophoretic pattern occur within the first 24 hours of life in the pig due to absorption of colostral V- and B-globulins. Rapid changes also occur in the subsequent 3-week period due to catabolism of serum V-globulin, the immediate anabolism of serum albumin and the absence of a significant amount of V-globulin production. Maximum production of serum V-globulin occurs between the ages of 3 and 6 months. Values of serum V- and B-globulins are relatively constant throughout life following the neonatal changes.

The Effect of Feeding Antibiotics to Chicks in the Presence of Fresh, Dried and Autoclaved Hen Feces

Warden, W. K. and Philip J. Schaible

Poultry Sci. XL(2): 363-367. 1961. (Journal Article 2628 from the Michigan Agricultural Experiment Station)

In a series of three battery experiments with 1-day-old broiler chicks, the effect of feeding broad or narrow spectrum antibiotics in the presence of hen feces was studied. When fresh hen feces was added daily to the all-mash antibiotic-free ration, 4-week weights and feed efficiency were depressed. Preliminary studies with limited numbers of birds indicated increased gram-positive intestinal bacterial population in the presence of fresh feces and antibiotic. Addition of 1 percent of dried (100 F.), or dried and autoclaved (15 lbs. pressure—30 minutes) feces did not alter growth rate, feed conversion or the population of certain selected gut microorganisms.

The broad-spectrum antibiotics (aureomycin and terramycin) restored growth equivalent to that of the unsupplemented controls when fresh fecal material was added to the diet. In the absence of fecal contamination, addition of either zinc bacitracin or broad spectrum antibiotics permitted more nearly the maximum growth potential in each instance.

Effects of Certain Nutrients upon Blood Spots in Chicken Eggs

POPE, C. W.; P. J. SCHIBLE AND L. E. DAWSON

Poultry Sci. XL(2): 377-382. 1961. (Journal Article 2629 from the Michigan Agricultural Experiment Station)

Blood spot incidences were studied with White Leghorns fed sodium and potassium chlorides, sodium carbonate, fat soluble vitamins, sources of unidentified growth factors. Comparisons were made on the performance of birds before and after receiving the experimental diets in order to minimize the influence of heredity and rate of production. Very low levels of vitamin A produced greater incidence of blood spots.

Liver analysis indicated that the defect was not caused by inability to mobilize vitamin A.

Nutrient-Element Composition of Leaves from Selected Species of Woody Ornamental Plants

DAVIDSON, HAROLD

Proc. of the Amer. Soc. for Hort. Sci. 76: 677-672. 1960. (Journal Article 2632 from the Michigan Agricultural Experiment Station)

Leaves of *Geditsia triacanthos, Acer platanoides, Syringa vulgaris, Euonymus alatus* and shoot tips of *Juniperus chinensis pfitzeriana, Taxus cuspidata expansa* and *Euonymus fortunei* were collected from five Michigan nurseries during June, July, and August, and analyzed for nine essential nutrient elements. All the elements except iron exhibited a significant variation with species. The analysis indicated that nitrogen and potassium decreased in concentration with time; calcium, magnesium, iron, and manganese increased; while phosphorus, boron and copper exhibited no statistical change in concentration with time. A table of average nutrient-element composition of the leaves of selected woody ornamental plants is included.

Influence of Gamma Radiation on the Microflora of Cucumber Fruit and Blossoms

ETCHELLS, J. L.; R. N. COSTILOW; T. A. BELL AND H. A. RUTHERFORD

Applied Microb. 9(2): 145-149. 1961. (Journal Article 2635 from the Michigan Agricultural Experiment Station)

During the 1959 harvest season, seven samplings of cucumber fruit and two of cucumber blossoms were irradiated in a Co^{60} gamma source with a dose rate of 0.20 megarep per hr. Each set of samples consisted of six to 14 individual lots sealed in plastic bags to provide for dosages from 0 to 3.0 megareps. Bacteriological tests were made on each sample for eight microbial groups: Total aerobes, total anaerobes, aerobic spores, anaerobic spores, coliform bacteria, acid-forming bacteria, yeasts, and molds. Firmness tests were run on the cucumber samples. Sterilization of small-sized cucumbers (¾-⅞ in. diam.) required about 3.0 megareps. Total microbial populations of cucumber flowers were reduced from about 20 billion organisms per g. to less than 100 by this dosage; for cucumber fruit, the reduction was from 16 million per g. to 0. The most resistant organisms encountered were the aerobic and anaerobic sporeforms; usually 1 to 10 spores survived 1.0 to 2.0 megareps. The coliform

bacteria, lactic acid bacteria, molds and yeasts were usually reduced to extremely low numbers by 0.50 to 0.75 megareps. Of these microbial groups, the coliforms and acid-forming bacteria appeared to be the most sensitive to the gamma rays. Increasing gamma dosages resulted in increasing losses in cucumber firmness.

Emergence during Growth of Cells in Strains of Brucella on Dye-Agar Media that Show Changes in Sulfur Metabolism

Huddleson, I. Forest

Bulletin of the World Health Organization. 24: 91-102. 1961. (Journal Article 2636 from the Michigan Agricultural Experiment Station)

Experiments have been conducted to determine the presence of cells in strains of Brucella that show differences in enzymatic activity. The cells examined were obtained from colonial growth on either basic fuchsin, thionin, or malachite green agar.

Cells that grew into visible colonies on the dye-agar mediums were studied to determine alterations in capability 1) to decompose a sulfur-containing compound in tryptose agar, 2) to decompose added urea, 3) to decompose added H_2O_2, and 4) alterations in agglutinability by monospecific serums.

Alterations in the activity of only one enzyme system was demonstrated in cells of certain colonies of particular strains of *Br. abortus*, *Br. melitensis*, and *Br. suis*. The enzyme in question is one that decomposes a sulfur-containing compound into H_2S and is found in most peptones and animal tissue extracts.

Cells were recovered from the growth of certain strains of *Br. abortus* on thionin (1 mg. 100 ml.) agar that showed either an increase in or no H_2S production.

Cells were recovered from the growth of certain strains of *Br. melitensis* on thionin (4mg. 100ml.) agar that produced H_2S. The amount measured was similar to that produced by typical strains of *Br. abortus*.

Cells were obtained from only one strain of *Br. suis* that behaved like those of one atypical type; they grew on both dye-agar mediums and produced no H_2S, or only traces of it, when grown on agar slants.

The mutant cells from the different strains of *Brucella* showed no change in agglutinability with monospecific serums.

The mutant cells obtained from certain strains of *Br. abortus*, *Br. melitensis*, and *Br. suis* by laboratory procedures, showed characteristics similar to certain atypical strains that have been isolated from infected animals and humans.

No evidence was obtained in this study which indicated that one species of *Brucella* can be transformed into another.

Estrus, Ovulation and Fertility in Gilts Subsequent to the Oral Admission of 6-Methyl-17-Acetoxyprogesterone

Nellor, J. E.; J. E. Ahrenhold, N. L. First and J. A. Hoefer

Jour. of Animal Sci. 20(1): 22-30. 1961. (Journal Article 2637 from the Michigan Agricultural Experiment Station)

Studies involving 134 mature gilts were conducted in order to determine whether 6-methyl-17-acetoxyprogesterone was capable of controlling the time of estrus and ovulation on a practical basis, that is, where the compound was added to the normal ration of groups of gilts fed together.

An average of 1.6 mg. of 6-methyl-17- acetoxyprogesterone per pound body weight daily, by twice-a-day feeding, provided an excessive progestational inhibition from which the gilts did not readily rebound following treatment. The optimal dosage determined for accurate control of the time of estrus and ovulation was .5 mg. per pound body weight daily, by twice-a-day feeding, in an average of 4 pounds of ration per gilt daily. Estrus occurred 4 to 5 days after the end of treatment in 87 percent of the treated gilts, and 78 percent of the gilts bred at the controlled estrus conceived normally.

The fertility at the controlled estrus, as judged by the recovery of fetuses from the uteri at 35 days of pregnancy, was comparable to control gilts bred at normal estrus, and averaged 11.1 per gilt. This study demonstrates that orally effective progestational compounds, in the normal ration, can control the time of estrus and ovulation, a procedure practical at the farm level.

The Fertility of Frozen and Unfrozen Ram Semen

FIRST, N. L.; A. SEVINGE AND H. A. HENNEMAN

Jour. of Animal Sci. 20(1): 79-84, 1961. (Journal Article 2644 from the Michigan Agricultural Experiment Station)

Five breeding experiments were involved in a study of the fertilizing ability of frozen and unfrozen ram semen. In the first experiment, each of 12 ewes were cervically inseminated with 75 million live sperm in 1 ml. of milk diluted thawed frozen ram semen, and each of 11 control ewes were inseminated with 480 million live sperm in 0.2 ml. of undiluted ram semen. Seventeen percent of the ewes inseminated with thawed frozen semen lambed as compared to 64 percent of the control ewes.

In a second experiment, each of 10 ewes were cervically inseminated with 81 million live sperm in 1 ml. of yolk-milk diluted, thawed frozen ram semen, and each of 10 control ewes were inseminated with 480 million live sperm in 0.2 ml of undiluted ram semen. Thirty percent of the ewes inseminated with thawed frozen semen lambed as compared to 60 percent of the control ewes.

In a third experiment, none of 47 ewes conceived when cervically inseminated with 100 million thawed frozen sperm contained in 1 ml. or 0.5 ml. of ram semen diluted in heated homogenized milk, yolk citrate or yolk citrate-glucose-urea diluter. The average motility of thawed semen 1 week after freezing was 70 percent. Forty-six ewes were cervically inseminated with 100 million unfrozen sperm diluted in the above three diluters. Eighty-six percent of the sperm were motile. The percent of ewes lambing after insemination of semen diluted in the three diluters: yolk citrate, 21.4 percent; milk 46.7 percent; and Y.C.G.U., 17.7 percent. Thirty-three percent of 24 ewes inseminated with 0.5 ml. of diluted semen lambed as compared with 23 percent of 22 ewes inseminated with 0.1 ml. Analysis of variance indicated no significant difference among diluters of volumes.

In a fourth experiment, 32 ewe lambs were each cervically inseminated with 1 ml. of milk diluted thawed frozen ram semen. No difference in lambing rate occurred between ewes inseminated once during estrus and those inseminated at 12-hour intervals throughout estrus. Twelve and one-half percent of the ewes inseminated lambed in each case. No difference in lambing rate occurred between ewes mated to a vasectomized ram before insemination and ewes that were not. Again, 12.5 percent lambed in each case.

In a fifth experiment, four of 17 ewes inseminated with frozen ram semen

lambed and 12 of 15 ewes inseminated with milk diluted unfrozen semen lambed. Motility stimulation by saline addition before insemination did not increase the lambing rate.

The Frozen Storage of Ram Semen

FIRST, N. L.; H. A. HENNEMAN; W. T. MAGEE AND J. A. WILLIAMS

Jour. of Animal Sci. 20(1): 74-78. 1961. (Journal Article Number 2645 from the Michigan Agricultural Experiment Station)

Fifteen ejaculates of ram semen were used in three experiments to study the glycerol requirement for freezing ram semen in a milk diluter. The addition of egg yolk to a milk diluter for added temperature shock protection before freezing was also investigated.

Ram sperm survival after freezing with 0, 2, 4, 6, 8, 10, 12 and 15 percent glycerol was curvilinear. The mean survival at 6 and 8 percent was significantly greater than at levels below 6 percent or above 10 percent.

A further study at glycerol levels of 5, 5.5, 6, 6.5, 7, 7.5 and 8 and 8.5 percent indicated no significant difference in motility after freezing between levels of 6 to 8.5 percent.

From a study of combinations of egg yolk and glycerol levels, significantly more sperm survived freezing with glycerol levels of 6 or 9 percent than survived when frozen in 12 of 15 percent glycerol. The addition of egg yolk to a heated homogenized milk diluter did not increase ram sperm survival after freezing. Furthermore the average sperm survival appeared to decrease as egg yolk increased.

Frozen ejaculates from each of two Hampshire rams were periodically thawed and examined for motility during a 14-month period of -79° C. storage. Motility declined the most rapidly during the first 2 months of storage, after which very little change in motility was observed.

Transmission of Bovine Leptospirosis by Coition and Artificial Insemination. A Preliminary Report.

SLEIGHT, S. D., J. A. WILLIAMS

Jour. of The Am. Vet. Med. Assoc. 138(3): 151-153. 1961. (Journal Article Number 2651 from the Michigan Agricultural Experiment Station)

A *L. pomona* infected bull transmitted the infection to two or eight exposed heifers. One heifer became infected by intravaginal inoculation of diluted semen and the other by a single natural service. Leptospirae were isolated from the semen of the infected bull. The epidemiological significance of these findings is discussed.

Drainage System Endurance in Organic Soils

CUTLER, W. A.; R. Z. WHEATON AND E. H. KIDDER

Agr. Engr. 42(2): 79-81, 85. 1961. (Journal Article 2652 from the Michigan Agricultural Experiment Station)

Four tile laterals were installed in a newly developed area of slightly acid organic soil in 1952. The underdrains included shale and concrete tile, galvanized

iron and fiber pipe. An inspection of these materials made in 1956 showed deterioration in the concrete tile furnished by three out of four manufacturers, some rusting of the galvanized pipe and a slight oblation of the fiber pipe.

Annual surveys of the elevation of the tile and the ground surface show that the tile subsided approximately 0.3 ft. the first year following drainage with little change in the next 6 years. The soil surface subsided 0.4 to 1.0 feet the first year following drainage with little change in the following 6 years.

The marsh hay that was used to blind over the tile was in excellent condition after 6 years.

Effects of Chlorpromazine of Mammary Glands of Rats

TALWALKER, P. K.; J. MEITES; C. S. NICOLL AND T. F. HOPKINS

The Amer. Jour. of Physiology. 199(6): 1073-1076. 1960. (Journal Article 2657 from the Michigan Agricultural Experiment Station)

The effects of chlorpromazine were determined on mammary growth and initiation of milk secretion in virgin rats, and on maintenance of mammary structure and secretion in postpartum rats after litter removal. When chlorpromazine was administered in doses of 5 or 15 mg kg body weight for 5 days, only the higher dose was effective in inducing lobulo-alveolar growth and initiating milk secretion in rats initially primed with 10 μg estradiol daily for 10 days. The higher dose of chlorpromazine also maintained mammary lobulo-alveolar structure and secretion in post-partum rats for 10 days after litter removal. Chlorpromazine produced a significant increase in adrenal weight and decrease in thymus weight, indicating adrenal stimulation. In estrogen-primed rats neither prolactin nor ACTH alone could initiate mammary secretion; however, they were effective when given in combination. The present data indicate that chlorpromazine promotes the secretion of both prolactin and ACTH. Hypophysectomy following estradiol treatment prevented chlorpromazine from initiating mammary secretion, showing that its effects are mediated through the anterior pituitary and not directly on the mammary gland.

Failure of Oxytocin to Initiate Mammary Secretion in Rabbits or Rats

MEITES, JOSEPH; P. K. TALWALKER AND C. S. NICOLL

Proc. of the Soc. for Exp. Biol. & Med. 105: 467-469. 1960. (Journal Article 2659 from the Michigan Agricultural Experiment Station)

1. Oxytocin failed to initiate lactation when injected four times daily into 45 mature female New Zealand White rabbits initially primed with estradiol or made pseudopregnant to develop their mammary glands. Prolactin injections initiated copious milk production in pseudopregnant rabbits. 2. Neither oxytocin nor vasopressin inhibited mammary involution or induced secretion in estrogen-primed rats, whereas injections of prolactin alone retarded mammary involution and addition of ACTH initiated mammary secretion. 3. It is concluded that oxytocin does not induce prolactin release in rabbits or rats.

Induction of Mammary Secretion in Rats by Electrical Stimulation

Maqsood, M. and J. Meites

Proc. of the Soc. for Exp. Biol. and Med. 106: 104-106. 1961. (Journal Article 2660 from the Michigan Agricultural Experiment Station)

Mature virgin female rats were injected subcutaneously with 10 μg estradiol daily for 10 days to produce mammary lobule-alveolar development. For the following 5 days, all except 10 controls were electrically stimulated twice daily for periods of 30 seconds on head, lumbar region, nasal mucosa and nipples. Control rats showed regression of the mammary glands to a bare duct system and no secretion, whereas almost all the electrically stimulated rats showed variable degrees of mammary secretion and maintenance of lobule-alveolar structure. Adrenal cortical stimulation in all electrically-stimulated groups was indicated by significant decreases in thymus weight. It is concluded that electrical stimulation of these areas in the rat induces release of both prolactin and ACTH, probably through autonomic and CNS pathways.

Drying Shelled Corn by Conduction Heating

Hall, Glenn E. and Carl W. Hall

Agr. Engr. 42(4): 186-187, 196. 1961. (Journal Article 2671 from the Michigan Agricultural Experiment Station)

The drying characteristics obtained by conduction heating were compared with convection heating of a thin layer of shelled corn. Kernels of corn were cut up before and during drying to determine the distribution of moisture and direction of movement of moisture during drying.

A heated plate with temperatures of 229, 189, 144, and 104° F. was used for conduction drying. In addition to the natural air current, air flows of 25, 50, and 100 feet per minute were used over the heated plate to carry moisture away.

The rate of drying was higher during the first part of drying by convection, but the conduction drying rate was higher during the latter part of drying. Drying from 56 percent to 15 percent, dry basis, moisture content, was faster for all four plate temperatures. Conduction drying from 56 to 15 percent, dry basis, at 229° F. required 49 minutes while convection drying required 54 minutes, or a saving of 10 percent in time. At 189° F., there was a saving by conduction drying of 15 percent in time required.

The Comparative Feeding Value of Lactic Acid and Grain for Dairy Cattle

Emery, R. S.; L. D. Brown; C. F. Huffman; T. R. Lewis; J. P. Everett and C. A. Lassiter

Jour. of Animal Sci. 20(1): 159-162. 1961. (Journal Article 2673 from the Michigan Agricultural Experiment Station)

Nutritive value of lactic acid was studied in a digestion trail, a growth and appetite trial with 2 groups of 10 heifers, and with rumen fermentation trials.

Rumen contents fermented 880 microg. lactate/ml. 4 hr. primarily due to the larger bacteria and protozoa. Lactic acid appeared to be entirely absorbed without affecting digestibility of other feeds. Group I heifers consumed 2 lb., 1 lb., 0.5 lb., and 0.25 lb. corn while group II heifers consumed 0.8 lb., 0.6 lb., 0.4 lb., and 0.2 lb. of 85 percent lactic acid respectively in four successive 14-day periods. Corn silage and hay were fed to appetite to both groups. Lactic Acid was mixed with the silage. Lactic acid depressed dry matter intake (Hay and silage) by 5.4 lb., 4.3 lb., 2.6 lb., 1.4 lb. in the four successive periods. Feed efficiency was increased in proportion to lactic acid intake. Lactate salts also increased efficiency but did not affect appetite.

Effect of Repeated Injections of Iron-Dextran upon Blood Hemoglobin and Hematocrit and upon the Iron and Myoglobin Concentration and Color of the Semimembranosus Muscle of Swine

HENRY, W. E.; E. R. MILLER AND L. J. BRATZLER

Jour. of Animal Sci. 20(1): 180-182. 1961. (Journal Article 2676 from the Michigan Agricultural Experiment Station)

Sixteen crossbred hogs were used in this study to determine the effect of repeated injections of iron-dextran on blood hemoglobin and hematocrits, and upon myoglobin concentration, total iron concentration and surface color of the *semimembranosus* muscle. Hemoglobin and hematocrit levels increased with repeated injections of iron-dextran through 9 weeks of age. The experimental animals, 16 and 22 weeks of age, had lower levels of hemoglobin and hematocrit than the control pigs. Although the myoglobin concentration increased with age, there was no apparent relationship to treatment. A highly significant correlation of $r = .75$ was found between hemoglobin level and myoglobin concentration. Surface color varied with myoglobin concentration. There was no apparent relationship to treatment. At no slaughter age was the injected ham color significantly darker than the non-injected ham of the same animal. Muscle iron was significantly higher in the experimental animals than in the control animals at 22 weeks of age. The injected ham contained, on the average, less total iron than the non-injected ham. No visible residual iron was apparent in groups of hogs slaughtered at 30, 40 and 120 lbs. There was a slight rust coloring of the external fat of ham of the hams of 22-week old animals which had received six injections totaling 1650 mg. of iron.

The Eighty-Year Period of the Dr. Beal Seed Viability Experiment

DARLINGTON, H. T. AND G. P. STEINBAUER

Amer. Jour. Bot. 48(4): 321-325. 1961. (Journal Article Number 2679 from the Michigan Agricultural Experiment Station)

Seeds of 20 species of plants were buried 80 years ago in inverted bottles of sand on the Michigan State University campus. Bottles have been dug up periodically in the intervening years and the seeds tested for viability. A bottle representing the 80-year period of burial was dug up this spring and the contents distributed uniformly on the surface of sterilized soil in the greenhouse.

Of the 20 species whose seeds were buried in 1879, only three have survivors. These are the same three that had survived the 70-year burial, namely: curled dock, Rumex crispus; evening primrose, Oenothera biennis; and moth

mullein, Verbascum blattaria. Only a few seeds of the first two species are viable and it appears that the survival period for these species is nearing an end. The third, however, has nearly as many survivors as 10 years ago, a remarkably high figure of between 70 and 80 percent viability. The significance of the slope of the survival curve for this species is discussed.

Brief comparisons are made between the results of the Beal experiment and other buried seed experiments. Comments are given on the ecological and agronomic significance of survival of buried seeds.

Fatty Acid and Lipide Distribution in Egg Yolks from Hens Fed Cottonseed Oil or Sterculia Foetida Seeds

Evans, R. J.; J. A. Davidson and S. L. Bandemer

Jour. of Nutr. 73(3): 282-290. 1961. (Journal Article Number 2682 from the Michigan Agricultural Experiment Station)

Laying hens were fed a ration containing 4.1 percent of fat, either unsupplemented, or supplemented with 2.5 percent crude cottonseed oil or 0.67 percent of *Sterculia foetida* seeds. Egg yolk lipides were fractionated on silicic acid columns, and each lipide fraction was analyzed for fatty acid distribution by gas-liquid chromatography. No differences in distribution of the various lipide fractions were observed among eggs from the three groups of hens. Feeding either *Sterculia foetida* seeds or crude cottonseed oil to laying hens caused them to lay eggs with an increased proportion of monoenoic acids. Over 50 percent of the fatty acids in eggs from hens fed cottonseed oil or *Sterculia foetida* seeds were saturated. The linoleic acid content of the phospholipides was fairly constant at about 55 percent, but the dienoic acids increased from 18 percent to 24 percent and the monoenoic acids decreased from 28 percent to 20 percent of the total fatty acids. Larger changes took place in the fatty acid distribution in the triglycerides, where the saturated acids increased from 39 percent to 62 percent, linoleic acid increased from 17 percent to 19 percent, and the monoenoic acids decreased from 44 percent to 19 percent of the total fatty acids in the case of hens fed *Sterculia foetida* seeds.

Comparison of Consecutive Cuts of the Same Muscle of Beef

Taylor, Betty; Dena C. Cederquist and Evelyn M. Jones

Jour. of Home Econ. 53(3): 190-192. 1961. (Journal Article Number 2683 from the Michigan Agricultural Experiment Station)

A comparison was made of the composition and properties of consecutive and matched steaks from the *semitendinosus* and *semimembranosus* muscles of six pairs of matched rounds of Choice grade beef. Total cooking loss, shear force value, press fluid, moisture, crude fat and nitrogen were determined on the cooked steaks. Crude fat, moisture, nitrogen, pH, collagen and elastin estimations were made on the raw samples. The matched steaks were relatively homogeneous except for these from the extreme anterior and posterior ends of both muscles. The adjacent steaks from the anterior and posterior portions of the *semitendinosus* muscle and the anterior portion of the *semimembranosus* muscle differed significantly in composition or in some of the properties. In the present study, a center portion of the *semitendinosus* muscle and the posterior half of the *semimembranosus* muscle were suitable for experimentation in the class room.

A Nucleotide-Peptide Isolated from Bovine Liver

WILKEN, DAVID R. AND R. G. HANSEN

Jour. of Biol. Chem. 236(4): 1051-1058. 1961. (Journal Article 2684 from the Michigan Agricultural Experiment Station)

A new nucleotide-peptide has been isolated from bovine liver. It is a 3′, 5′-adenosine diphosphate-peptide derivative which also contains a third phosphate group presumably on the peptide. The peptide consists of glutamic acid, glycine, B-alanine, cysteic acid, taurine, and as yet an unidentified ninhydrin positive component. The amino-terminal amino acid of the peptide is glutamic acid. The nature of the nucleotide-peptide linkage is discussed.

Gibberellin Modification of Flower Sex Expression in Cucumis Sativus L.

BUKOVAC, M. J. AND S. H. WITTWER

Advances in Chem. 28:80. 1961. (Journal Article Number 2695 from the Michigan Agricultural Experiment Station)

Flower sex expression of cucumbers can be modified by treatment of seedlings with several growth regulating substances. With the exception of gibberellin, chemicals tend to reduce the number, or suppress the development, of staminate flowers, and increase the number or accelerate the development of pistillate flowers. Gibberellin, in contrast, increases the number of staminate flowers in monoecious cucumbers and results in the formation of staminate flowers on gynoecious cucumbers which otherwise would produce only pistillate flowers. Relative to the promotive effects of gibberellin on staminate flower formation and vegetative extension, GA_4 is approximately 10-fold more active than GA_3.

Application of the Equation of the Curve of Diminishing Increment to Swine Nutrition

HEADLEY, V. E.; E. R. MILLER; D. E. ULLREY AND J. A. HOEFER

Jour. of An. Sci. 20(2): 311-315. 1961. (Journal Article 2697 from the Michigan Agricultural Experiment Station)

The average live weight-feed consumption data collected from 1,200 pigs from weaning to market weight accurately conform to the equation of the curve of diminishing increment. Calculated cumulative feed consumption values were almost identical to observed values with both comparing well to NRC standards. Applications of the equation were made to determine cumulative feed consumption, instantaneous and cumulative efficiency of feed utilization and instantaneous and cumulative maintenance requirement at any specified live weight at which the "animal-plus-feed" cost per pound of live weight gain is the least is also presented.

Inactivation of Prolactin by Human Blood Serum and Plasmin (Fibrinolysin)

HOPKINS, THOMAS F.; JOSEPH MEITES AND ALBERT RATNER

Proc. of the Soc. Expt. Biol. and Med. 106: 140-41. 1961. (Journal Article 2698 from the Michigan Agricultural Experiment Station)

Ovine prolactin (7.5 I.U.) was incubated for 2 hours at 37° C. with human blood serum and human fibrinolysin. Moderate decreases of prolactin activity

occurred after incubation in 10 percent serum, and somewhat greater losses occurred when incubated in 45 percent serum. Fibrinolysin caused almost complete inactivation of prolactin. The relationship of the serum inactivator system to the fibrinolysin system remains to be established.

The Effect of Artificial Light and Ambient Temperature on the Thyroid Secretion Rate and Other Metabolic Measures in Sheep

Hoersch, T. M.; E. P. Reineke and H. A. Henneman

Jour. of An. Sci. 20(2): 358-362. 1961. (Journal Article 2705 from the Michigan Agricultural Experiment Station)

Quantitative measures of the thyroid secretion rate were obtained on 64 ewes using the thyroxine substitution method. These animals were maintained under controlled conditions of light and temperature. There were six variants in light exposure ranging from 4 through 24 hours per day and two temperatures, 50° and 90° F.

Decreasing the ambient temperature from 90° F. to 50° F. induced a threefold increase in the thyroid secretion rate.

Increasing the hours of light in increments of 4 hours produced a biphasic effect within the range 4 through 24 hours per day. By increasing the illumination from 4 daily to 12, thyroid activity was progressively depressed, but with added light above 12 hours the thyroid secretion rate steadily rose.

An augmented secretion by the thyroid gland was associated with increased gains in body weight and improved feed efficiency.

Jack Pine Geographic Variation--5-year Results from Lower Michigan Tests

Arend, John L.; Norman F. Smith; Stephen H. Spurr and Jonathan W. Wright

Papers of the Mich. Acad. of Sci., Arts and Letters. XLVI: 219-238. 1961. (Journal Article 2721 from the Michigan Agricultural Experiment Station)

In the fall of 1951, seeds were collected from 29 average jack pine (*Pinus banksiana* Lamb.) stands in Michigan, Wisconsin, and Minnesota. The seedlings were grown for 2 years in a Wisconsin nursery, then outplanted in 17 localities in the three states. A 4-replicated, randomized block design was used in each outplanting. The three test plantings in lower Michigan were measured in 1958, when the trees were 7 years old from seed. The data for all three plantings were subjected to analysis of variance, and only statistically significant differences were considered. During the first 7 years, the four Lower Peninsula seed origins grew 10 percent faster than Wisconsin or Minnesota seedlings, and 20 percent faster than trees from seed collected in Michigan's Upper Peninsula. In each of the three test plantings, the relative performance of the various seedlots was similar, indicating no interaction between site and genotype. There were also genetic differences in susceptibility to the white pine weevil, bark beetles, and the red-headed pine sawfly. These differences were slight and had little geographic significance.

Toward Effective Integration of Knowledge Situations in a Theory of Managerial Behavior

BIRD, ALAN R. AND CURTIS F. LARD

Jour. of Farm Econ. XLIII(1): 137-141. 1961. (Journal Article 2727 from the Michigan Agricultural Experiment Station)

The likely fruitfulness of adding the following two new knowledge situations to the Interstate Managerial Survey classification is illustrated.

Involuntary learning is a situation wherein the manager is unwilling to learn more since the cost of additional information equals or exceeds its value to him. However, some outside force makes it necessary to learn, or for some learning to occur regardless of the volition of the manager.

Forced inaction is a situation in which the entrepreneur thinks he has enough information to act satisfactorily. Otherwise, he would enter a (voluntary) learning or a positive risk action situation, except that he is restrained from doing so by circumstances beyond his immediate control. Sickness or social censure would be such circumstances.

Soil Moisture Measurement Improved

BOUYOUCOS, GEORGE JOHN

Agr. Engr. 42(3): 136-138. 1961. (Journal Article 2728 from the Michigan Agricultural Experiment Station)

New sensitive plaster of paris blocks have been developed which can reveal changes in soil moisture at as low a moisture tension as 75 mm. of mercury. The sensitivity is accomplished by simply increasing the pore space of the blocks. This is attained by using higher ratio of water to plaster of paris. The screen electrodes are placed parallel to the long surface and they are $\frac{1}{4}$-inch apart. The new blocks are considered to be the most sensitive and accurate made thus far.

A Comparison of Virus Isolates, Dwarf-fruit and Spy 227 - Lethal

CATION, DONALD

Phytopathology. 51(2): 104-106. 1961. (Journal Article 2749 from the Michigan Agricultural Experiment Station)

Isolates of the dwarf fruit and Spy 227-lethal virus diseases were compared on Hyslop, R12740-7A, Spy 227 and Lord Lambourne apple varieties. Degree of dwarfing and distortion of Hyslop fruit was more severe for the dwarf-fruit isolate, the only definite difference indicated. Both isolates produced stem pitting of Hyslop, the chlorotic leaf spot syndrome on R12740-7A, and chlorotic spotting of Spy 277 leaves. No rubbery wood or mosaic symptoms were indicated on Lord Lambourne. Spread to immediately adjacent leaves was observed after 12 years for the dwarf-fruit and 9 years for the Spy 227-lethal isolate in a manner indicating natural root graft inoculation. A more distinct stunting of Hyslop trees by the dwarf-fruit isolate was attributed possible to the inoculation of trees at a younger age. The fruit difference noted was postulated as resulting from two different viruses, different strains of the same virus, or possible contaminants concurrent with the isolates.

Edible High-Acid Powder Made from Skimmilk and Cottage Cheese Whey

BARNES, J. C.; C. M. STINE AND T. I. HEDRIK

The Milk Prods. Jour. 52(4): 8-9, 34. 1961. (Journal Article 2757 from the Michigan Agricultural Experiment Station)

Lactobacillus bulgaricus was used to develop the acidity in condensed skimmilk (31.0 percent solids) to 3.5 percent or in skimmilk to 1-7 percent which was subsequently condensed to approximately 31.0 percent solids. Condensed cottage cheese whey was mixed with the skimmilk solids in equal amounts on the basis of total solids. The mixture was spray dried with care to minimize color change and scorched particles by control of the heat exposure time and outlet air temperature during the drying process. The dry product should have not less than 10 percent acidity and a moisture content should be within 3.0 to 4.0 percent.

The outlets for this high-acid, dry product are principally the bakery and dry mix industries.

Equine Intra-articular Injections

VAN PELT, R. W.

M.S.U. Vet. 21(2): 54-62. 1961. (Journal Article 2768 from the Michigan Agricultural Experiment Station)

The value of injecting adrenocortical steroids or their synthetic analogs into a joint cavity has been discussed. Contrast arthrograms, employing anatomical specimens of the fetlock, hock, and stifle, have been presented to better visualize the synovial sacs in each of the aforementioned joints. Preparation of the patient for arthrocentesis and injection of the joint has been discussed. The need for an aseptic technique has been stressed as an invaluable aid to obtaining favorable clinical response. Two approaches to arthrocentesis of the fetlock joint have been described: (1) a proximal approach through the dorsal diverticulum of the metacarpo-phalangeal sac; (2) a distal approach directly into the metacarpo-phalangeal joint cavity at its point of articulation. Arthrocentesis and injection of the hock joint is made through the dorsomedial cul-de-sac of the tibio-tarsal sac; which in turn communicates with the proximal intertarsal sac. Two other alternatives for entrance into the tibio-tarsal articulation are discussed. Arthrocentesis and injection of the stifle joint is made via the femoro-patellar sac, which usually communicates with the medial and lateral sac of the femoro-tibial articulation.

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